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A BIOLOGICAL STUDY OF THE ASIATIC PALM WEEVIL, RHYNCHOPHORUS FERRUGINEUS (OLIVIER), (CURCULIONIDAE, COLEOPTERA)[1]

GETULIO B. VIADO AND AVELINO E. BIGORNIA[2]
Of the Department of Entomology

WITH TWO PLATES AND FOUR TEXT FIGURES

The Asiatic palm weevil, *Rhynchophorus ferrugineus* (Olivier), is one of the most injurious pests of coconut and other palms in the Philippines. Although tell-tale signs of attack in the field are not so conspicuous as in infestation by *Oryctes rhinoceros* Linn., the palm weevil is more destructive in that the result of its work is almost invariably fatal to the host plant. The young coconut trees are very susceptible to its attack. The grubs feed on the "cabbage" and other soft portions of the tree. The outer shell of the trunk is left intact, thus making it difficult to notice the damage until it is too late to save the affected plants. The young unopened leaves usually wilt when the "cabbage" is totally destroyed.

Banks (1906) gives an account of the damage caused by this weevil on coconuts in the Philippines, with a short description of the egg, full-grown grub, pupa, and adult. Woodworth (1921), in his host index of injurious insects on Philippine crops, lists the red palm weevil under coconut but not under other palms. Copeland (1931) reviews the biology of the insect and states that it is most commonly known in Ceylon and British Malaya as the red beetle, although it is also known as the Asiatic palm weevil. Its native name in Ceylon is "kandapanuwa" and in Annam it is called "con-duon". In the *Handbook of Philippine Agriculture* (1939), p. 211, a short summary of how the weevil may gain entrance into the coconut palm and suggestions for its control are given.

The palm weevil is also reported in other countries. Hunger (1920) gives a short description and a brief account of the habits of *Rhynchophorus* in the Dutch East Indies. Leefmans (1920) studied the biology of this weevil in Java. Corbett (1932) published on the biology of a closely related species, *R. schach* Olivier, in the Federated Malay States.

Dammerman (1929) gives a summary of the information then extant on the biology of *Rhynchophorus ferrugineus* F. (*signaticollis* Chevr.). He

[1] Experiment Station Contribution No. 1528. Part of the data used here was included in a thesis presented by the junior author for graduation, 1949, with the degree of Bachelor of Science in Agriculture.

[2] The authors wish to acknowledge their indebtedness to Dean L. B. Uichanco for valuable suggestions.

notes that this weevil is widely distributed all over Southern Asia to Australia and that it is known in Malaya as "kumbang merah" and in the Philippines as "dalipos" (Samar Visayan).

The present work was conducted in the entomology laboratory of the College of Agriculture, in the Los Baños Economic Garden, San Pablo Coconut Experiment Station, Calauan, and Alaminos, all in Laguna province, to study (*a*) the life history of the weevil, (*b*) its host plants, and (*c*) possible methods of control.

MATERIALS AND METHODS

Large glass jars of convenient size (fig. 1) were used for feeding, mating,

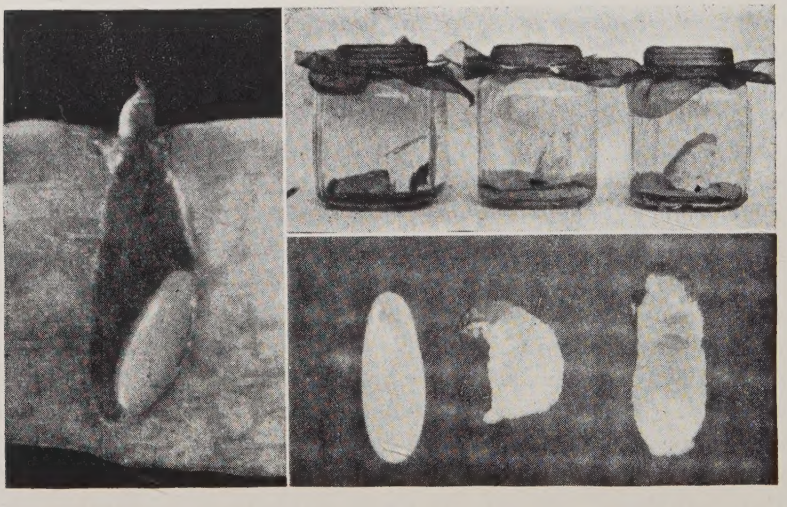

Fig. 1.—Left panel shows sagittal section of oviposition hole showing egg and plug *in situ*. (×15). Right upper panel shows receptacles used in rearing adults for total eggs laid, longevity test, and period of fecundity. (×1/5). Lower panel shows, left to right, a newly laid egg, grub just out of the chorion, and second-instar grub coming out of the exuviae. (×16).

egg-laying, and longevity studies. The jars were lined at the bottom with blotting paper which was kept moist with water and changed weekly. They were covered with cheese cloth which was later changed with plastic fabric when it was found that the adults could work their way out through the cheese-cloth covers.

Each grub was reared in a cage consisting of a pair of glass plates, 18 by 10 centimeters, between which a cardboard or wooden frame is sandwiched. Thicker frames were used as the grub grew bigger. The device (fig. 2) was bound with rubber bands and twine to prevent the grub from

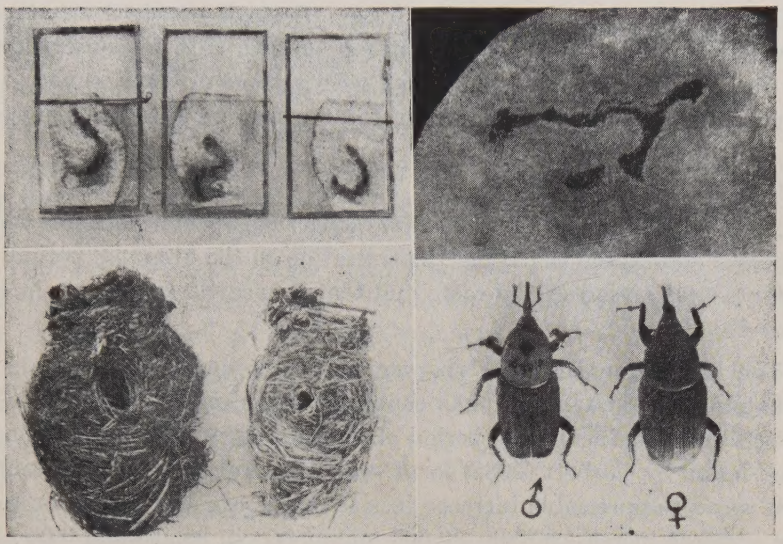

Fig. 2.—Upper panel, left, shows receptacles made of glass plates and frames used in rearing grubs and pupae. (×1/5). Upper panel, right, shows tunnel of a third-instar grub. (×2). Lower panel, left, shows pupal cocoons with peephole used in observing the pupa. (×1–1/4). Lower panel, right, shows an adult male and adult female. (×1–1/3).

escaping. A shallow wooden box with four legs set on pans containing water and a removable cover was used as stand and receptacle for all these cultures.

For studies on incubation, chunks of convenient sizes of the "cabbage" of three- to five-year-old coconut seedlings were exposed to the weevils in the rearing jars and changed every day. This also served as feed for the adults.

Each newly hatched grub was transferred into a small cavity at the center of a slice of the coconut "cabbage" of about 1 to 1.5 millimeters thick and about 25 square centimeters area. This slice with the grub lying in a small cavity that had been cut in the center for its accommodation, was placed between glass plates. To guard against undue pressure as well as prevent the escape of the grub, strips of cardboard or wood of about the same thickness as the feed were inserted between the edges of the glass. It was found necessary to slice the feed to approximately the same thickness as the grub to permit easy observation of the insect. The feed was changed once every two days. As the grub increased in thickness, the thickness of the feed and that of the enclosing frame were correspondingly increased. Coarser feed was given as the grubs grew older. Representative samples of each instar were preserved for study.

The grub pupated in the glass frame. A small peephole was made at approximately the middle of the cocoon on one side for observation of pupation. This hole was kept covered with a piece of black paper to keep off light when not in use. Samples of the pupae were killed and preserved.

LIFE HISTORY

After hatching from the egg, *Rhynchophorus ferrugineus* passes through nine larval stadia, the last being the transition to the prepupal period. The developmental period of the male and female weevils are shown in tables la and lb.

The incubation period of the egg was three days. Any egg that did not hatch after that period was found to be infertile. Leefmans (1920) reported the same incubation period of the egg. This figure is also the same as that found by Corbett (1932) for *R. schach*, a close relative of this species. There was an appreciable increase in size of the egg the day prior to hatching. A mean increase of 0.09 ∓ 0.006 millimeters in length and 0.06 ∓ 0.004 millimeters in width was noted.

The eggs were laid in the soft tissues of the coconut "cabbage". Figure 1 shows an egg *in situ*. The egg was laid singly in a cavity made by the female, the posterior pole of the egg being glued to the bottom of the cavity. The egg puncture or cavity was about twice as long as the egg and may be vertical or slanting. The opening of the egg puncture was plugged with a soft pinkish-white, subconical structure which hardened in a few minutes and became opaque after one day [Pl. II(23) and fig. 1]. This plug was provided with two holes for the protection of the egg from enemies and at the same time for aeration of the cavity.

The eggs hatched at any time of the day, depending upon the time they were laid. The chorion broke off at the free end or anterior pole and the young grub crawled out, head first, by peristaltic movement. Figure 1 shows a newly laid egg, a grub just out of the chorion, and a second-instar grub half-way out of the exuviae. After leaving the chorion, the grub remained at rest and showed no signs of activity until after about thirty minutes to three hours had elapsed. Then the grub started feeding on any side of the cavity. If the feed happened to be tough, the grub did not eat all that it excavated. Most of the frass was deposited at the side of the tunnel. Figure 2 shows the tunnel made by a young grub.

Data on the duration of the different larval stadia are presented in tables la (for males) and lb (for females). According to these tables, the first stadium ranged from 1 to 2 days in both sexes, with a mean of 2.0 days for either the male or the female. Only one out of the 18 males and none of the females molted one day after hatching.

Except for one female and one male, which molted 3 days after the first molt, all the 36 grubs molted 2 days after the first molt. The mean of the second stadium was 2.1 days for either the male or the female.

The third stadium ranged from 2 to 5 days in both sexes, with most of the grubs (93 per cent of the males and 81 per cent of the females) undergoing the third molt 2 days after the second. The average for the male was 2.3 days and for the female, 2.6 days.

The fourth stadium ranged from 2 to 5 days for either sex, with about 87 per cent molting after 3 days. The mean for the fourth stadium was 2.9 days for the male and 3.1 days for the female.

The fifth larval stadium of both sexes was from 2 to 7 days, with most of the grubs (86 per cent in the males and 64 per cent in the females) undergoing the fifth molt 3 days after the fourth molt. The mean for the fifth stadium was 3.2 days for the males and 3.5 days for the females.

The sixth stadium ranged from 3 to 8 days in both sexes, with most of the grubs (57 per cent in the males and 64 per cent in the females) undergoing the sixth molt 3 days after the fifth molt. The mean for the sixth stadium was 4.3 days for the males and 4.1 days for the females.

The seventh stadium ranged from 3 to 7 days in both sexes, with 80 per cent of the males and 52 per cent of the females molting 4 days after the sixth molt. The mean for the seventh stadium was 4.8 days for the males and 4.9 days for the females.

The eight stadium ranged from 4 to 10 days in both sexes, with 83 per cent in the males and 30 per cent in the females molting 6 days after the seventh molt. The mean was 5.8 days for the males and 7.3 days for the females.

The ninth stadium ranged from 4 to 16 days in both sexes, with most of the grubs (92 per cent in the males and 59 per cent in the females) completing the pupal cocoon 7 days after the molt. The mean for the ninth stadium was 7.6 days for the males and 8.9 days for the females.

The prepupal period ranged from 2 to 11 days in both sexes, with 57 per cent in the males and 29 per cent in the females pupating 3 days after completing the cocoon. The mean was 4.3 days for the males and 5.4 days for the females. Leefmans (1920) reported the range of from 3 to 6 days for this period.

The pupae of the males developed into adults in 11 to 19 days after pupation, most of them (80 per cent) emerging in 14 days after pupation. The pupal period of the females was 12 to 19 days, with 71 per cent completing pupation in 14 days. The mean pupal period was 13.7 days for the males and 14.3 days for the females. The adult male spent from 2 to 6 days, with an average of 3.6 days, in the cocoon before emergence. The

figures corresponding to the female were 1 to 8 days, with a mean of 3.6 days. Leefmans (1920) found that the pupal period varied from 13 to 17 days and that the adult spent 11 to 18 days in the cocoon prior to emergence.

The mean length of the larval stage was 34.9 days for the males and 38.0 days for the females. The analysis of variance presented in table 2, comparing the developmental period for the two sexes, shows that the difference between the two means is not significant. In the open the shortest larval period found by Leefmans (1920) was 2 months, while in the laboratory it was 3.5 months.

The total preadult period (from egg to emergence of adult) for the males ranged from 45 to 68 days, with a mean of 54.8 days; for the females, 45 to 67 days, with a mean of 58.7 days. These findings confirm Dammerman's (1929) figures, which give about 2 months.

The grubs molted at any time of the day. The larva was sluggish and ceased to feed when it was about to molt. The process of molting lasted from 30 minutes to several hours. The exuviae were dragged along as the grub moved about until these were ultimately freed from the body. In few instances the grub was observed to devour the exuviae except the head capsule.

It took the pupating grub from 2 to 4 days (tables la and lb), with a mean of 2.1 days for the male and 2.7 days for the female to construct its cocoon; the time required was apparently conditioned by the availability of fibrous material in the media. After the cocoon was completed, the grub grew quiescent; its body contracted, turned dirty cream in color, shortly cast off its last larval skin, and became a pupa.

A description of the different stages is as follows:

Egg. (fig. 1). Length 2.57 mm., diameter 0.95 mm. Elongated, posterior end considerably larger than anterior end, both smoothly rounded; opaque when newly laid, pale yellow when about to hatch; anterior pole ochraceous and semi-transparent just before hatching; chorion regularly reticulated, surface smooth, soft and pliable or elastic.

First-instar grub. (figs. 1 and 3). White to creamy, legless, fleshy grub 3.5 mm. long from frons to tip of ninth abdominal segment, 1.2 mm. at broadest segment of abdomen. Head 1.0 mm. long and 0.7 mm. wide; body integument soft, with numerous microscopic chitinized asperities; spiracles, nine pairs (prothoracic, 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, and 9th abdominal).

Second-instar grub. (fig. 3). Creamy to yellowish white. Very similar to preceding instar in shape and structures, except size. Average-sized grub of this instar has the following measurements: length of body, 4.5 mm., width at widest portion of abdomen 1.5 mm.; head 1.3 mm. long and 1.0 mm. wide.

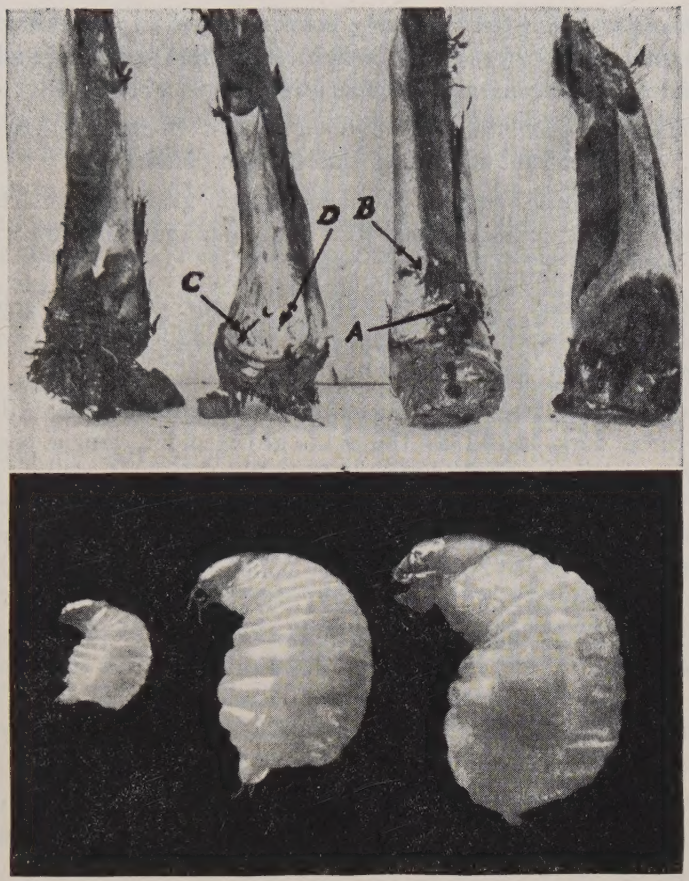

Fig. 3.—Upper panel shows coconut seedlings about one year old showing oviposition holes (A, B, C, and D). (×1/4). Lower panel shows, left to right, first-instar, second-instar, and third-instar grub. (×5).

Third-instar grub. (fig. 3). Similar in color, body conformations, and structures to preceding instars. Average-sized grub 6.2 mm. long and 2.6 mm. at widest portion of abdomen; head 1.9 mm. long and 1.4 mm. wide.

Fourth-instar grub. Pale yellow, body structures similar to those of preceding instars. Length of body (from frons to tip of abdomen) 8.6 mm., width at widest portion of abdomen 3.5 mm.; head 2.4 mm. long and 1.8 mm. wide.

Fifth-instar grub. General color pale yellow. Similar in body conformations and structures to preceding instars. Average-sized grub 11.2 mm. long and 4.4 mm. wide; head 3.8 mm. long and 2.8 mm. wide.

Sixth-instar grub. General body color pale yellow; head dark brown. Similar to preceding instars except in size. Body 16.5 mm. long and 6.8 mm. wide; head 5.1 mm. long and 3.7 mm. wide.

Seventh-instar grub. Similar to above instars. Body 23.5 mm. long and 11.2 mm. wide; head 6.4 mm. long and 4.8 mm. wide.

Eighth-instar grub. Similar to seventh-instar grub in color, shape, and structures, exclusive of size. Body 31.2 mm. long and 17.5 mm. wide; head 7.9 mm. long and 5.7 mm. wide.

Ninth-instar grub. [Pl. I(1)]. Similar to other instars in color, shape and structures except in size. Length of body 42.5 mm. and width 20.7 mm.; head 10.3 mm. long and 7.6 mm. wide.

Head [Pl. I(2)] free, subglobular, pale yellow immediately after eighth ecdysis, turns dark brown as the grub grows older, longer than broad, smoothly rounded above when viewed from front; frontal sutures deep and distinct. Adfrontal sutures originate from about midpoint of each frontal suture, extending posteriorly, delimiting adfrontal region. Epicranium with four pairs of dorsal epicranial setae which probably correspond to *des* 1, *des* 3, *des* 4, and *des* 5 of Anderson's (1947) *Pissodes strobi* (Peck); *des* 1 and *des* 3 moderately long, borne on isolated sclerites along the middle and base of adfrontal suture, respectively; *des* 4 much shorter than *des* 3, *des* 5 about as long as *des* 3. With two pairs of lateral epicranial setae; *les* 1 very long, while *les* 2 much shorter. Ocelli rudimentary, located on epicranium laterad of antennae.

Frons subtriangular, bears four pairs of setae, which probably correspond to *fs* 1, *fs* 3, *fs* 4, and *fs* 5 of Anderson (1947); *fs* 1 as long as *fs* 4; *fs* 3 and *fs* 5 coequal in length and much longer than *fs* 1 or *fs* 4. Antenna two-jointed, fleshy, located at lateral angles of frons. First joint stout, almost globular; second slender and short.

Clypeus broadly subtrapezoidal, provided with one pair of setae located along suture separating clypeus and epistoma, one on each side.

Labrum [Pl. I(3), (4)] flap-like, subtriangular, broader than long, anteriorly rounded. Ectal surface of labrum bears four pairs of long, large, simple labral setae and 12 pairs of flattened marginal setae. Epipharynx with two median spines and without asperities. Very different from that of Anderson's (1948) *Rhynchophorus palmarum.*

Mandible [Pl. II(12), (13)] stout, dark-brown, highly chitinized triangular structure with two short setae. Tip with a single blunt tooth; mola slightly corrugated with shallow irregular depressions.

Maxilla [Pl. I(5), (7), (8), (10)] with L-shaped cardo. Mala bluntly rounded at tip, bearing two long unbranched setae and a row of six dichotomous setae along distal margin. Maxillary palp [Pl. I(9)] extends slightly

beyond mala, two-jointed, borne on a large fleshy palpifer; proximal joint thick, subcylindrical, slightly broader than long; distal joint finger-like about as long as wide, one third as wide as basal joint, with highly sclerotized sides; bears numerous terminal sensory papillae. Baso-ectal surface of mala bears a group of branched setae, asperitic at base.

Labium [Pl. I(10)] subconical, bearing three pairs of simple setae. Ectal surface of prementum with three pairs of simple setae, two pairs of which are located on the dome-shaped ligula, while the other pair is located between the bases of the labial palpi. Labial palpus two-jointed, the basal joint stout, and distal joint slender, finger-like, bearing numerous sensory papillae on distal surface.

Hypopharynx [Pl. I(5), (6)] subtrapezoidal, fleshy, occupying almost entire floor of buccal cavity; densely setose except on sides and a median area which are bare.

Thorax distinctly three-segmented. Pronotum not divided into lobes, more sclerotized than mesonotum, leathery, bearing large prothoracic spiracles about three times as large as most of abdominal spiracles. Pronotum with six pairs of setae arranged in a transverse row along anterior region. Prosternum bearing seven pairs of setae of various lengths. Mesonotum bilobed, bearing four pairs of setae arranged in a single transverse row on second lobe and one pair on first lobe.

Mesosternum with four pairs of setae. First metathoracic lobe bearing one pair of notal, one pair alar, and three pairs of sternal setae, with four pairs of setae on second lobe.

Abdomen divided into ten segments each, except segments VIII and X, bearing a pair of spiracles. Segments I to VII trilobed, interpreted by some authors as the praescutum, scutum and scutellum; third lobe or scutellum bearing five pairs of setae; alar area with one short seta; epipleural area with a short seta and pedal area bearing single short seta. Segment VIII smaller than the more anterior segments; tergum declivous. Segment IX small, flattened dorso-posteriorly and terminating into four fleshy latero-caudal projections, each bearing a pair of long setae; a pair of short setae between eighth pair of abdominal spiracles on the tergal plate. Segment X small, ventrally located; small anal slit located at about middle of posterior end of the tenth segment. There are eight pairs of dark-brown spiracles on the abdomen, a pair being located on the tergal plate of segment IX. The spiracles on segment IX [Pl. II(14)] are three times as long as other abdominal spiracles and are provided with four prominent setae along the medial edge.

After the ninth stadium, the grub constructed the cocoon with fibers from the host plant. The grub did not cut the fibers of the plant while feeding. These fibers were woven into a compact, ellipsoidal cocoon.

Prepupation. After finishing the cocoon, the grub became quiescent. This marked the beginning of the prepupal period which ended when the grub was transformed to pupa. The average prepupal period was 4.3 days for the male and 5.4 days for the female.

Pupation. The true pupal period started from the time the grub cast off its last larval skin to the emergence of the adult. The mean pupal period of the male was 13.7 days and that of the female, 14.3 days. The pupa was motile, turning around in the cocoon when disturbed and making a characteristic rasping sound. The appendages were free. The last larval skin was usually deposited at the posterior end of the cocoon.

Pupa. [Pl. II(17), (18), (19)]. Motile, exarate, ochraceous, and elongated; widest at thorax, gradually tapering anteriorly and posteriorly. Apparently average-sized pupa 33.5 mm. long and 18.5 mm. wide.

Head compressed on antero-ventral region of prothorax. Snout folded posteriorly along sternum, with antenna extended laterally along femur of foreleg. Frontal surface of snout with four pairs of setae; most proximal pair longer than distal three pairs which are fine.

Pronotum subovate, ochraceous, covered with short numerous spines, especially along margins. Forelegs folded over prosternum, tibia overlapping anterior half of mesolegs. Tarsus aligned posteriorly along sternum.

Meso- and metathoraces partly visible, major area overlapped by folded wings. Scutellum subtriangular between base of wings. Wings folded obliquely over meso- and metapleura, terminating over the first abdominal sternite; forewings over and about three-fourths the length of hind wings. Forewing with five tuberculate parallel ridges. Middle legs arranged similarly as forelegs. Hind legs partly covered by wings, folded in the same fashion as other legs.

Abdomen subelliptical, ochraceous, divided into seven subequal segments. Tergites with a row of regular transverse, dorsal short spines, and with numerous shallow lateral folds. Seven bilabiate spiracles visible, located on latero-anterior margin of each tergite. Abdominal sternites similar to the tergites in shape and size. Fourth, fifth, and sixth sternites highly convoluted.

Adult male. (fig. 2). General color of body reddish brown to almost black, legs lighter colored than body; elytra dark red to almost black, slightly pubescent, margins bordered by a black band; pronotum with variable black spots.

Head prolonged into a slender snout curved downward, about one-fourth entire length of body, widest at base, dorsal side of distal two thirds bearing tufts of short stiff hairs; eyes inconspicuous, with a pinhead-like depression between them at the base of snout; mandibles trident, closely fitting each other. Antenna geniculate with a distinct club at the distal

end, eight-segmented, inserted in groove at the side of the beak in front of the eyes; scape elongated, about half entire length of antenna; pedicel small, sub-triangular; first four joints of clavola small, annular and subequal, the fifth trapezoidal; club dark orange to reddish brown, compressed, with sensory hairs at distal area, about three times as wide as other segments.

Prothorax subconical from dorsal view, as long as head, posterior margin convex, lateral margin absent, prosternum delimited posteriorly by propleurae; at first glance, prosternal sclerite appearing fused together. Foreleg flattened, densely setose on inner edge or margin of both femur and tibia; front coxa globose, widely separated; trochanter triangular, very small; femur about three times as long as broad, hairy on the ventral proximal two thirds, distal third grooved to receive tibia when leg is flexed; tibia subequal in length, about one half as wide as femur, hairy on its entire ventral side; tibial spine at distal end well developed; tarsus subequal in length and about half as wide as tibia, four-segmented, densely pubescent below on the first segment. Tarsal segment I compressed, about twice as long as broad; II similar to I; III subequal to I in length, dilated and bilobed; IV half the entire length of tarsus, with very few scattered hairs below; with two simple tarsal claws. Posterior margin of prothorax fringed by brown pubescent hairs entally.

Mesothorax small, subrectangular, about one-sixth the entire length of thorax; mesonotum not visible dorsally, covered entirely by pronotum; scutellum small, triangular; mesopleurae transverse with distinct pleural sutures; mesoepisternum and mesoepimeron subquadrate and subequal in size; mesosternum small, sparsely pubescent, rectangular in shape with a notch at the base; mesoleg very similar to foreleg in size and appearance except that coxa is not so prominent as that in foreleg.

Metathorax rectangular, metanotum about two and one-half times as long as wide, about twice as long as mesonotum; metapleuron visible, not overlapped by wing, about two and one-half times as long as wide; metaepisternum subtrapezoidal, as long as mesosternum; metaepimeron small and triangular; metasternum large and rectangular, about one and one-third times wider than long; metaleg similar in appearance to the other legs except as to coxa which is transversely subovate and not prominent; femur and tibia about half longer than other legs.

Elytra smooth and velvety to the touch, subrectangular, about two and one-third times as long as wide, wings with five shallow furrows each, tip truncate leaving pygidium exposed. Hind wing long and narrow, about twice as long as wide.

Abdomen slightly flattened dorsally, convex ventrally, as wide as thorax, gradually narrowing to the tip. Tergum seven-segmented, pubes-

cent, as wide as thorax, subequal in length except in last tergite which is subconical and three times longer than the others. Abdomen eight-segmented ventrally, smooth and shiny, first two sternites fused or immovably united with suture between them indistinct. First sternite one and one-half times as long as second; second twice as long as third; third, fourth, and fifth sternites subequal in length. Pygidium subtriangular, posterior margin beset with stiff setae. Genitalia retractile.

An apparently average-sized male measured as follows: length of body (from base of snout and exclusive of appendages) 30.5 mm., width 13.4 mm.; length of snout 8.5 mm., width 0.8 mm.; length of antenna 7.2 mm., width 0.8 mm.; length of elytron 16.5 mm., width 7.2 mm.; length of hindwing 26.5 mm., width 6.8 mm.; length of foreleg 16.5 mm.; length of middleleg 14.8 mm.; length of hindleg 17.2 mm.

Adult female. (fig. 2). Very similar to male both in body color, size, spots and structures, except in the snout. The difference between the lengths of the snouts of both sexes was highly significant (table 2) in favor of the female. The same table also shows that the difference between the widths of the snouts was also highly significant, indicating that the snout of the male is stouter than that of the female.

An apparently average-sized female measured as follows: length of body (from base of snout and exclusive of appendages) 32.0 mm., width 14.6 mm.; length of snout 9.5 mm., width 0.6 mm.; length of antenna 7.6 mm., width (at widest part of antenna) 0.9 mm.; length of elytron 17.0 mm., width 7.7 mm.; length of hindwing 28.8 mm., width 7.0 mm.; length of foreleg 17.2 mm., middleleg 15.7 mm., hindleg 18.9 mm.

Newly emerged adults were light brown and soft, with characteristic dark spots on pronotum visible. They assumed characteristic brown-red color several hours after emergence. The adult did not emerge from the cocoon immediately after emergence from the pupal skin.

The weevils sought darkness upon emerging from the cocoon. They hid under the bottom lining of the jars and only came out to feed and to mate.

Apparently, the adults mated at any time of the day; at least, they were observed in copula in the morning and late in the afternoon. Half of the weevils (9 out of the 18 females) mated upon emergence. The male trailed the female wherever it went, occasionally tapping the female's elytra with its antennae. After several minutes, the male mounted the female. The forelegs of the male were wound around the prothorax, the tarsi almost meeting at the prosternum of the female. The middlelegs were similarly wound tightly around the mesothorax of the female, the tarsal claws anchored near the base of the coxa of the middlelegs. The tarsus of the male was placed near the coxa of the hindlegs of the female. Copulation took

place from 15 to 30 seconds only. During this operation the antennae of the male incessantly tapped the snout of the female as it moved about, unmindful of the male. Copulation took place more than once.

In laying its eggs, the female went around the coconut "cabbage" and selected a suitable location for oviposition by tapping the surface with its antennae as it moved about. It did not stop where the feed was tough and fibrous. After locating an appropriate place, it began to dig a hole with its mandibles. It took the insect three to five minutes to make the cavity as deep as two-thirds the length of the proboscis. The time spent in making the oviposition hole depended upon the texture of the "cabbage". After finishing the hole, the female turned around completely and prodded with the extended ovipositor to locate the hole while the abdomen moved up and down. When the ovipositor hit the hole, it was inserted and a single egg was laid. Most of the eggs were laid in inclined position, the larger end or posterior pole first. This end was glued to the bottom of the cavity. As the ovipositor was pulled out, a plug covering the aperture was deposited. This plug is described elsewhere in this paper.

The total number of eggs laid by a female ranged from 162 to 350, with a mean of 221.4 ∓ 13.67 eggs (table 3). Leefmans (1920) found that the maximum number of eggs laid by the female was 531. Dammerman (1929) reported that Corbett observed a maximum of 832 eggs laid by a female. The total number of infertile eggs ranged from 15 to 44, with a mean of 22.9 ∓ 2.31 for each female. The percentage of hatchability of the eggs laid by a single female ranged from 85.2 to 93.9 per cent, with a mean of 89.6 ∓ 0.69. This mean is very close to the figure (87 per cent) obtained by Leefmans (1920). Table 4 and figure 4 give the weekly mean number of eggs laid and hatched, and the percentage of eggs hatched for 14 females. These show that the percentage of infertile eggs increased with the age of the mother weevil. No infertile egg was laid on the first week; but by the time the weevil was seven weeks old, all of the eggs laid were infertile.

The period of fecundity of the females studied ranged from 33 to 70 days, with a mean of 56.6 ∓ 2.45 days (table 3). Of the mean number of eggs laid during the first six weeks, 81.3 per cent were laid during the first three weeks.

The longevity of the male adults in confinement ranged from 63 to 109 days, with an average of 83.6 days; the females under identical conditions had a life span ranging from 39 to 72 days, with a mean of 59.5 days. The difference in the longevity of the male and of the female weevils is highly significant (table 2). This indicates that the male lives longer than the female. Leefmans (1920) found that the longest period of life of adults in captivity was 107 days.

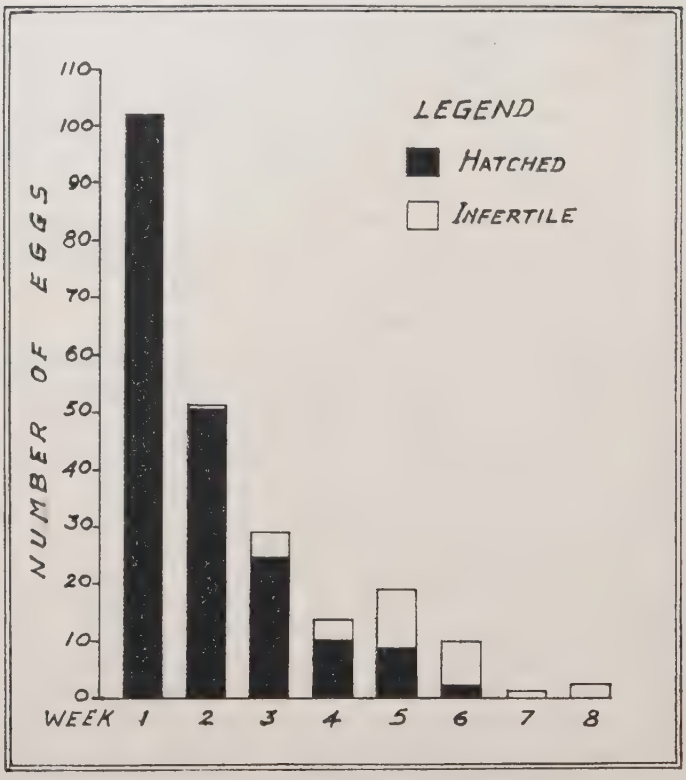

Fig. 4.—Weekly mean number of eggs laid, hatched, and infertile eggs for the fourteen females.

HOST PLANTS

Leefmans (1920) reported that, besides coconut, *Rhynchophorus ferrugineus* also attacks *Metroxylon sagu* Rottb., *Arenga pinnata* (Wurmb.) Merr., *Elaeis guineensis* Jacq., *Corypha gebanga* Bl., *Phoenix sylvestris* Roxb., and *Borassus flabelliformis* L. In Malaya, Corbett (1932) reported that a close relative of this species, *R. schach* Oliv., attacked *Metroxylon sagu*, *Arenga pinnata*, *Elaeis guineensis*, *Livistonia cochinchinensis* Mart., *Oncosperma tigillaria* (Jack) Ridl., and *Oncosperma horridum* (Griff.) Scheff.

In the present work the pest was observed attacking buri palm (*Corypha elata* Roxb.), coconut (*Cocos nucifera* Linn.), kaong (*Arenga pinnata* [Wurmb.] Merr.), pugahan (*Caryota maxima* Blume and *C. cumingii* Lodd.), African oil palm (*Elaeis guineensis*), royal palm (*Oreodoxa regia* HBK.), and betel nut palm (*Areca catechu* Linn.). It seems, however, that the insect prefers the coconut, buri, and kaong to the other palms. The falling-off of the mutilated young leaves of the crown of the coconut palm and the presence

of frass and empty cocoons around the base of the plants were used by the writers as main guide in locating infested trees in the field. This method was resorted to when the tree was tall and difficult to climb. Trees suspected to harbor the insect, especially at the early stage of infestation, were visited a number of times until the cause of the damage was determined.

The "cabbage" of kaong was tried as feed for the grubs in the laboratory. The larvae devoured the feed as fast as it did the coconut "cabbage". Mature sugar-cane stalks (*Saccharum officinarum* Linn.) were also tried, and the insect fed on and laid eggs in them. Some of the grubs developed into adults. The mortality among the grubs, however, was high and the adults emerging from them were abnormally small and misshapen.

NATURAL ENEMIES

During the study a species[3] of mites was observed as ectal parasite on both the pupa and adult. The mites attached themselves along the sutures of the sternum of the adult and along the thinly chitinized regions of the pupae. The adult, however, was not adversely affected by the parasite, but an infested pupa may not develop into adult. The mites did not attack the grubs. No other parasite or predator was observed except chickens and birds which fed on exposed grubs and pupae. No parasite of this insect in Java was reported by Leefmans (1920). Corbett (1932), likewise, did not report any natural enemy of *R. schach* in Malaya.

CONTROL MEASURES

An extensive survey of the surrounding coconut plantations was conducted by the writers, and observations on the mode of infestation and other habits of the insect were made.

In plantations consisting of old trees (30 to 50 years old) the damage of the pest was more or less negligible. When old trees, however, were found infested or killed by the palm weevil, the crown was invariably the only portion damaged, even though there were notches on the trunk. Apparently, the insect gained entrance into the crown through injury on the crown. In the cases observed the old trees infested by *Rhynchophorus* were previously attacked by the black beetle (*Oryctes rhinoceros* Linn.) as shown by the characteristic damage done by the latter on the fronds.

In plantations of young trees (5 to 15 years old) instances were found where the pest entered the tree through lesions on the trunk (usually in the form of cracks) caused by burning of cogon and other grass. Cutting of wounds, steps, or notches on the trunk of young trees were also found to be open invitations to the pest. Wounds on the trunk caused by carabaos tied to it also served as entrances of the weevil. Cases were noted wherein the

[3]Deposited in the Department of Entomology for future work.

pest apparently found its way inside through the area of the root system just above the ground and below the shell of the trunk. The surface and the crown of a tree so affected were sound, but the tissues inside the trunk were completely destroyed by the grubs. These observations confirm those of Banks (1906) and Copeland (1931), who reported that in the provinces of Laguna and Tayabas the weevil gained entrance only through wounds or injuries on the trunk, and that sound trees were not susceptible to attack.

In abandoned plantations where the nuts were allowed to fall and germinate, grubs or pupae, or both, were collected from the seedlings, particularly from the one- or two-year-old plants. Figure 3 shows infested coconut seedlings collected from abandoned plantations. The photograph shows oviposition punctures (A, B, C, and D) on the bases of the young petioles.

From the above observations and reports of various workers on the subject, it would seem that the most effective methods of control would be the following:

a. Control of *Oryctes* infestation, which usually makes the initial opening for the entrance of the red palm weevil. Control of *Oryctes* consists in destroying its breeding places, killing the beetles in the holes of trees, baiting, and trapping. It is claimed that tapped trees are seldom attacked by the weevil.

b. The use of kaong palm trunks as bait and trap gives promise as a good method of control. The only disadvantage in this method is that a species of small black ants is lured to the trap, rendering the bait unattractive to the weevils.

c. Cracks on the trunk of young trees caused by fire and other agencies should be remedied, preferably avoided, inasmuch as they are common points of entrance of the pest.

SUMMARY

1. The total developmental period (incubation, larval and pupal stages) of *Rhynchophorus ferrugineus* under laboratory conditions ranged from 45 to 68 days, with an average of 54.8 days for the male and 58.7 days for the female. The female has a longer developmental period than the male, but the difference is not significant.

The time required to complete the different developmental steps under laboratory conditions was as follows:

Incubation period — 3 days.
First stadium — 1 to 2 days, average 2.0 days for either the male or the female.
Second stadium — 2 to 3 days, average 2.1 days for either the male or the female.
Third stadium — 2 to 5 days, average 2.3 days for the male and 2.6 days for the female.

Fourth stadium — 2 to 5 days, average 2.9 days for the male and 3.1 days for the female.

Fifth stadium — 2 to 7 days, average 3.2 days for the male and 3.5 days for the female.

Sixth stadium — 3 to 8 days, average 4.3 days for the male and 4.1 days for the female.

Seventh stadium — 3 to 7 days, average 4.8 days for the male and 4.9 days for the female.

Eighth stadium — 4 to 10 days, average 5.8 days for the male and 7.3 days for the female.

Ninth stadium — 4 to 16 days, average 7.6 days for the male and 8.9 days for the female.

Prepupal period — 2 to 11 days, average 4.3 days for the male and 5.4 days for the female.

Pupal period — 11 to 19 days, average 13.7 days for the male and 14.3 days for the female.

2. The adult male outlived the adult female. The longevity of the adult ranged from 39 to 72 days in the females and 63 to 109 days in the males, with an average of 83.6 days for the male and 59.5 days for the female. The mean difference between the two sexes was highly significant.

3. The differentiating characters between the male and the female adults were:

a. The male had shorter and stouter snout than the female.

b. Tufts of short stiff hairs were found on the anterior two thirds of the male snout, while the female snout was bare. This character, however, was not constant.

4. The eggs were laid singly in the soft tissues of the plant in a cavity made by the female with its mandibles.

5. The total number of eggs laid by a female ranged from 162 to 350, with a mean of 221.4 ∓ 13.67.

6. The period of fecundity ranged from 33 to 70 days, with a mean of 56.6 ∓ 2.45 days; 81.3 per cent of the fertile eggs were laid by the females during the first three weeks.

7. The grubs fed on the "cabbage" and other soft portions of the coconut.

8. *Rhynchophorus ferrugineus* was observed in the field on coconut (*Cocos nucifera* Linn.), buri palm (*Corypha elata* Roxb.), kaong (*Arenga pinnata* [Wurmb.] Merr.), African oil palm (*Elaeis guineensis*), betel nut palm (*Areca catechu* Linn.), pugahan (*Caryota maxima* Blume and *C. cumingii* Lodd.), and royal palm (*Oreodoxa regia* HBK.).

9. Only one species of ectoparasite, a mite, was observed on the pupae and adults. The weevil, however, was observed not to be adversely affected by the parasite, but an infested pupa might not develop into adult. The mites did not attack the grubs

10. Baiting and trapping trials gave indications that these methods of control may help minimize the ravages of this insect.

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DESCRIPTION OF ILLUSTRATIONS

PLATE I

Ninth-instar grub

Fig. 1. Grub, sinistral aspect. ×10.
2. Head, frontal aspect. ×20.
3. Labrum and clypeus, ectal aspect. ×36.
4. Epipharynx. ×36.
5. Relative position of hypopharynx and maxillae. ×36.
6. Hypopharynx. ×52.
7. Right maxilla, ectal aspect. ×36.
8. Right maxilla, ental aspect. ×36.
9. Maxillary palpus. ×98.
10. Relative position of labium and maxillae, ectal aspect. ×36.
11. Labial palpus. ×98.

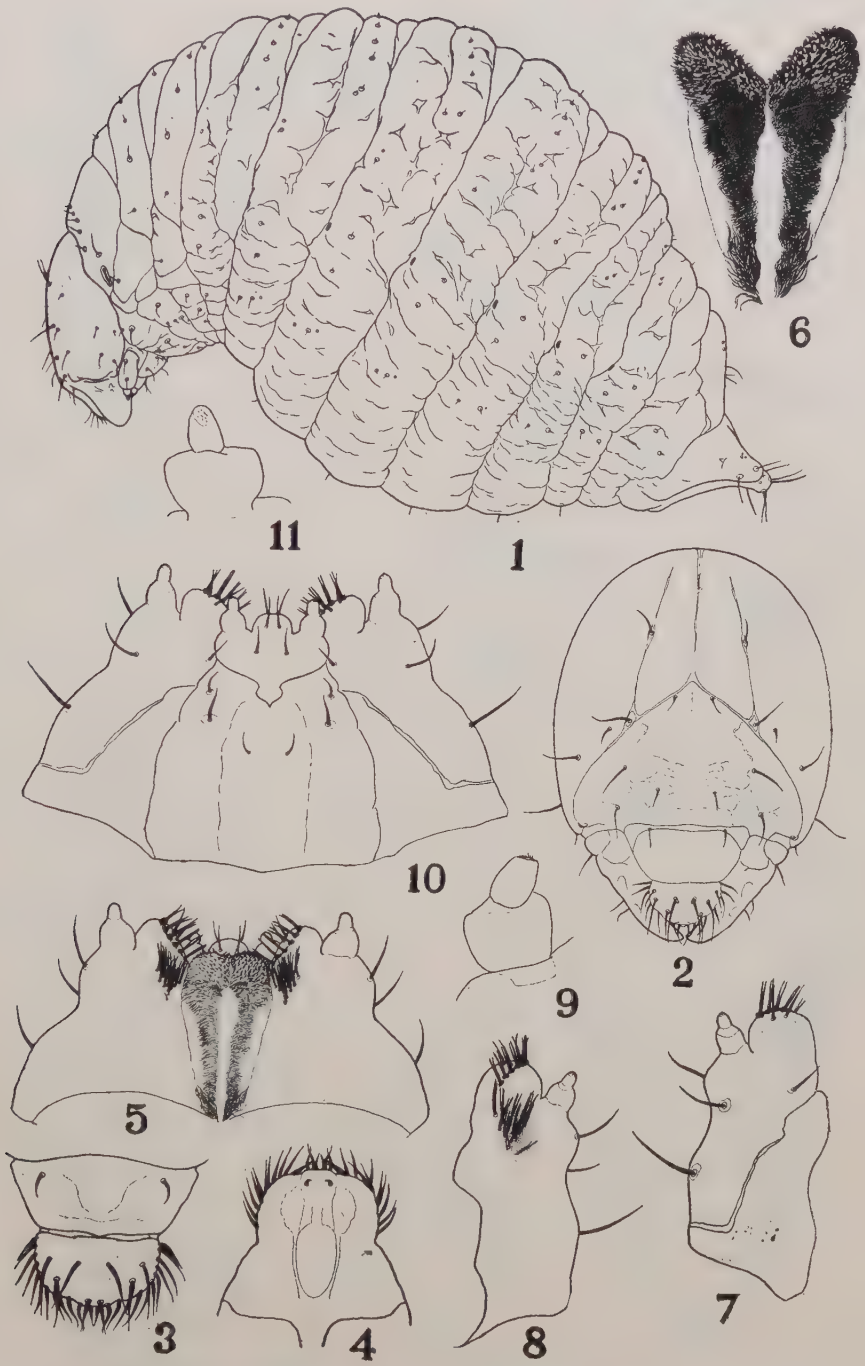
PLATE II

Ninth-instar grub

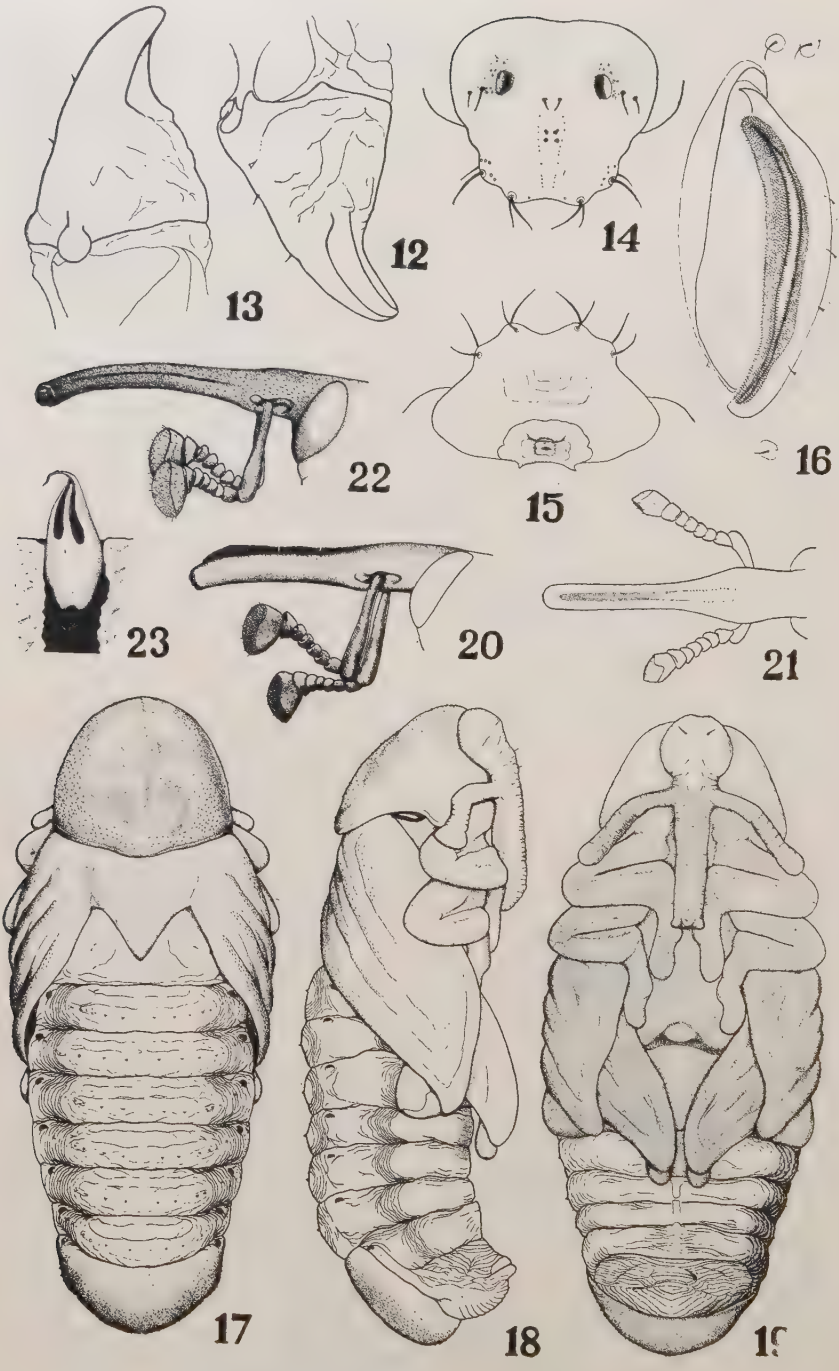
Fig. 12. Mandible, ectal aspect. ×36.
13. Mandible, ental aspect. ×36.
14. Tip of abdomen, dorsal aspect, showing spiracles. ×18.
15. Tip of abdomen, ventral aspect, showing last (10th) abdominal segment and anal opening. ×18.
16. Last abdominal spiracle, right. ×254.

Other stages

17. Pupa. dorsal aspect. ×10.
18. Pupa, sinistral aspect. ×10.
19. Pupa, ventral aspect. ×10.
20. Snout of adult male, sinistral aspect, showing tufts of hair on dorsal side. ×14.
21. Snout of adult male. dorsal aspect, showing arrangement of tufts of hair. ×14.
22 Snout of adult female. sinistral aspect. ×14.
23. Plug of oviposition hole. ×60.



VIADO AND BIGORNIA: THE ASIATIC PALM WEEVIL



VIADO AND BIGORNIA: THE ASIATIC PALM WEEVIL

TABLE 1a
Summary table of developmental periods of males

PERIOD OF DEVELOPMENT	NUMBER OF INDIVIDUALS		FIDUCIAL LIMITS (COMPUTED RANGE)
		days	*days*
Incubation period			
Maximum			
Minimum			
Average	20	3.0 ∓ 0.00	3.0
First stadium			
Maximum		2	
Minimum		1	
Average	20	2.0 ∓ 0.00	2.0
Second stadium			
Maximum		3	
Minimum		2	
Average	20	2.1 ∓ 0.05	2.0 — 2.3
Third stadium			
Maximum		4	
Minimum		2	
Average	20	2.3 ∓ 0.20	1.7 — 2.9
Fourth stadium			
Maximum		5	
Minimum		2	
Average	20	2.9 ∓ 0.19	2.3 — 3.5
Fifth stadium			
Maximum		4	
Minimum		2	
Average	20	3.2 ∓ 0.13	2.8 — 3.6
Sixth stadium			
Maximum		8	
Minimum		3	
Average	20	4.3 ∓ 0.35	3.3 — 5.4
Seventh stadium			
Maximum		7	
Minimum		3	
Average	20	4.8 ∓ 0.30	3.9 — 5.7
Eighth stadium			
Maximum		10	
Minimum		4	
Average	18	5.8 ∓ 0.41	4.6 — 7.0
Eighth molt to construction of cocoon			
Maximum		9	
Minimum		3	
Average	12	4.0 ∓ 0.51	2.5 — 5.5
Duration of construction of cocoon			
Maximum		3	
Minimum		1	
Average	14	2.1 ∓ 0.09	1.8 — 2.4
Ninth stadium			
Maximum		15	
Minimum		5	
Average	18	7.6 ∓ 0.72	5.4 — 9.8
Prepupal period			
Maximum		11	
Minimum		2	
Average	14	4.3 ∓ 0.71	2.2 — 6.4
Pupal period			
Maximum		17	
Minimum		11	
Average	20	13.7 ∓ 0.44	12.4 — 15.0

TABLE 1a (continued)
Summary table of developmental periods of males

PERIOD OF DEVELOPMENT	NUMBER OF INDIVIDUALS		FIDUCIAL LIMITS (COMPUTED RANGE)
		days	*days*
Spent in cocoon before emergence			
Maximum		6	
Minimum		2	
Average	14	3.6 ∓ 0.27	2.8 — 4.4
Total developmental period of grub			
Maximum		48	
Minimum		25	
Average	18	34.9 ∓ 1.71	29.8 — 40.0
Total developmental period (egg to adult)			
Maximum		68	
Minimum		45	
Average	18	54.8 ∓ 1.75	49.6 — 66.1

TABLE 1b

Summary table of developmental periods of females

PERIOD OF DEVELOPMENT	NUMBER OF INDIVIDUALS		FIDUCIAL LIMITS (COMPUTED RANGE)
		days	*days*
Incubation period			
Maximum			
Minimum			
Average	19	3.0 ∓ 0.00	3.0
First stadium			
Maximum			
Minimum			
Average	19	2.0 ∓ 0.00	2.0
Second stadium			
Maximum		3	
Minimum		2	
Average	19	2.1 ∓ 0.07	1.9 — 2.3
Third stadium			
Maximum		5	
Minimum		2	
Average	19	2.6 ∓ 0.20	2.0 — 3.2
Fourth stadium			
Maximum		5	
Minimum		2	
Average	19	3.1 ∓ 0.20	2.5 — 3.7
Fifth stadium			
Maximum		7	
Minimum		2	
Average	19	3.5 ∓ 0.25	2.8 — 4.3
Sixth stadium			
Maximum		8	
Minimum		3	
Average	19	4.1 ∓ 0.33	3.1 — 5.1
Seventh stadium			
Maximum		7	
Minimum		3	
Average	19	4.9 ∓ 0.24	4.2 — 5.6
Eighth stadium			
Maximum		9	
Minimum		4	
Average	18	7.3 ∓ 0.37	6.2 — 8.4
Eighth molt to construction of cocoon			
Maximum		9	
Minimum		2	
Average	12	4.6 ∓ 0.68	2.6 — 6.6
Duration of construction of cocoon			
Maximum		4	
Minimum		2	
Average	14	2.7 ∓ 0.19	2.1 — 3.3
Ninth stadium			
Maximum		16	
Minimum		4	
Average	18	8.9 ∓ 0.89	6.2 — 11.6
Prepupal period			
Maximum		11	
Minimum		2	
Average	14	5.4 ∓ 0.80	3.0 — 7.8
Pupal period			
Maximum		19	
Minimum		12	
Average	19	14.3 ∓ 0.50	12.8 — 15.8

TABLE 1b (continued)
Summary table of developmental periods of males

PERIOD OF DEVELOPMENT	NUMBER OF INDIVIDUALS		FIDUCIAL LIMITS (COMPUTED RANGE)
		days	*days*
Spent in cocoon before emergence			
Maximum		8	
Minimum		1	
Average	14	3.6 ∓ 0.47	2.2 — 5.0
Total developmental period of grub			
Maximum		55	
Minimum		25	
Average	18	38.0 ∓ 1.78	32.7 — 43.3
Total developmental period (egg to adult)			
Maximum		67	
Minimum		45	
Average	18	58.7 ∓ 1.49	54.2 — 63.2

TABLE 2

Summary table comparing various characters of the male and female

CHARACTERS COMPARED	MALE		FEMALE		d	POOLED VARIANCE	S_x	t	REMARKS
	Number of Individuals	Mean	Number of Individuals	Mean					
Total developmental period of grubs, in days	18	34.9	18	38.0	3.1	51.758	2.40	1.29	Insignificant
Total developmental period from egg to adult, in days	18	54.8	18	58.7	3.9	45.353	2.11	1.85	Insignificant
Longevity of adult, in days	14	83.6	14	59.5	24.1	162.728	4.82	4.99	Highly significant
Length of snout, in millimeters	38	8.23	38	9.33	1.1	0.318	0.13	8.27	Highly significant
Width of snout, in millimeters	38	0.76	38	0.66	0.1	0.002	0.01	9.09	Highly significant

TABLE 3

Total number of eggs laid, hatched, infertile eggs, percentages of eggs hatched, and period of fecundity of 14 females

		FIDUCIAL LIMITS (COMPUTED RANGE)
Eggs laid		
Maximum	350	
Minimum	162	
Average	221.4 ∓ 13.67	180.4 — 262.4
Eggs hatched		
Maximum	306	
Minimum	142	
Average	198.5 ∓ 12.25	161.8 — 235.3
Infertile eggs		
Maximum	44	
Minimum	15	
Average	22.9 ∓ 2.31	16.0 — 29.8
Per cent hatched		
Maximum	93.9	
Minimum	85.2	
Average	89.6 ∓ 0.69	87.5 — 91.7
Period of fecundity		
Maximum	70	
Minimum	33	
Average	56.6 ∓ 2.45	49.3 — 64.0

TABLE 4

Weekly mean number of eggs laid, hatched, and per cent hatched of 14 females

WEEKS	NUMBER LAID	NUMBER HATCHED	PER CENT HATCHED
1	102.2	102.2	100.00
2	50.9	50.5	99.21
3	28.2	25.2	89.36
4	13.6	10.4	76.47
5	18.2	8.1	44.51
6	9.6	2.7	28.13
7	1.8	0	0
8	3.0	0	0

OBSERVATIONS ON THE RANGE HABITS OF GROWING CHICKS[1]

AVELINO B. MANUEL

Raising chicks to weaning age is one of the most difficult phases of poultry production. Although it is not definitely known whether or not the present system of raising chicks on the range is the most efficient and profitable under prevailing conditions, the studies of Ragat (1939)[2] and Igtanloc (1941)[3] showed that it was decidedly more advantageous to raise chicks on the range than to raise them indoors or in batteries. The present study was conducted for the purpose of observing the different activities and pasture habits of chicks. A knowledge of these pasture habits would help satisfy the requirements the chicks need, thereby increasing the efficiency of production.

So far no study has been made regarding the activities of chicks on the range in the Philippines and, possibly, in any country. The only study made of a somewhat similar nature was that of Fronda and Paje (1930)[4] who observed the activities of layers in and outside the laying house.

MATERIALS AND METHODS

Plan of the study. Three sets of observations each covering a period of 12 weeks were made: the first, from January 20, 1947, to April 6, 1947; the second, from April 7, 1947, to June 29, 1947; and the third, from July 1, 1947, to September 29, 1947. Two hundred and twenty-eight Los Baños Cantonese chicks were used in the study. The chicks were divided equally into two lots. A broody Los Baños Cantonese hen was used in the naturally brooded lot designated as lot I, and a fireless brooder in the artificially brooded lot designated as lot II.

Yards and brooding houses. Two enclosed adjoining yards approximately 35 meters square, with a poultry wire fence between them, were used. Concentric circles of ridges divided each yard into zones three meters apart, the brooding house being in the center. There were six zones in all; the

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[1]Experiment Station Contribution No. 1529. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, March, 1948. Prepared in the Department of Animal Husbandry under the direction of Professor F. M. Fronda.

[2]RAGAT, MODESTO. 1939. A comparative study of chicks raised indoors and outdoors. Philippine Agriculturist **28**: 593–600.

[3]IGTANLOC, PEDRO. 1941. Comparative studies on the rate of growth and maturity of battery and range-raised pullets. Philippine Agriculturist **29**: 687–694.

[4]FRONDA, F. M. AND P. S. PAJE. 1930. Observations on the activities of fowls in the laying house. Philippine Agriculturist **19**: 157–177.

sixth zone was the space outside the 15-meter distance from the brooder house. Bamboo pegs about a meter high marked each zone. The yards were covered with green succulent grass. A uniform distribution of shade was made by cutting down unnecessary shrubs and by planting shade plants in the bare spaces of the yards.

Each lot had a brooder house about 90 cm. high, elevated 10 cm. from the ground, with wooden floor and walls, galvanized iron roofing, and one square meter of floor space. Each brooding house was provided with doors on all the sides to allow the chicks to go out freely.

Feeds, feeding, and management. The College growing ration consisting of the following ingredients by weight was used:

Fine rice bran	56.25 parts
Ground corn	18.75 "
Copra meal	5.00 "
Shrimp meal	20.00 "

The chicks in both lots were given the same ration which was placed in two feeding troughs near the brooder house. When it rained, these feeding troughs were placed inside the house. Feed and water were made available to the birds at all times during the day. The watering troughs were placed in the shaded area outside the house in the first zone.

Observations made. Observations on the pasture habits and activities of the chicks were made daily at 6:00 and 9:00 o'clock in the morning, at 12:00 o'clock noon, and at 3:00 and 6:00 o'clock in the afternoon. After the last daily observation had been made, the doors of the brooding houses were closed. They were opened again about 5:30 o'clock the following morning. The observations in the first set were started after the chicks were one week old; but in the succeeding sets, the observations were made soon after the chicks were removed from the incubator. The number of birds found within each zone and the number of those seen engaged in various activities at each hour of observation were recorded. To do this, the observer had to stay at a safe distance so as not to disturb the normal activities of the birds. All the observations were reported in percentage. The total number of birds observed in the 7-day periods was used in determining the weekly percentages.

The various activities recorded during each hour of observation were the following: (a) feeding; (b) drinking; (c) idling or standing, or walking about without any apparent purpose; (d) scratching and picking; (e) running around, flying, or fighting; and (f) staying in the shade.

Other records. Records of the time of sunrise and sunset throughout the period of observations in Los Baños were obtained from the Weather Bureau, Manila.[5] Records of rainfall and temperature during the periods

[5]The author is indebted to Director Casimiro del Rosario, of the Weather Bureau, Manila, for supplying the necessary data.

covered by the observations were obtained from the weather observation station of the College.

RESULTS AND DISCUSSION

Weaning time. Weaning time was reckoned from the time the hen started pecking at and abandoning the chicks. The naturally brooded chicks (lot I) were weaned by the hen on the seventh week in the first set of observation, on the sixth week in the second set, and on the eighth week in the third set.

Extent of range covered. The figures obtained in this study showed that during the first week, the farthest zone that the chicks went to was the third, which was nine meters distant from the brooder house. Three per cent of the chicks in lot I, naturally brooded, in the third set were observed in this zone at 6:00 o'clock, and 10.9 per cent in the second set at 9:00 o'clock in the morning. In all of the three sets none of the chicks in lot II, artificially brooded, were observed beyond the second zone which was six meters from the house. In this lot, only 4.1 per cent of the chicks reached zone 2 at 9:00 o'clock in the morning during the first week of the second set of observation. The chicks in both lots, however, began to go out on the second day and stayed within a meter distance from the brooder house. Most of the chicks were outside at 9:00 o'clock in the morning. On the third day, a few chicks in lot I ventured as far as three meters away because the hen led them out on that day. At this age, the chicks in lot II were only within two meters from the brooder house. From the fourth to the seventh day, the chicks in lot I were at different places within the third zone. None of the chicks in lot II were beyond the second zone at this period.

During the second week of the second set, the chicks in lot I were in the sixth zone at 9:00 o'clock in the morning. The chicks in lot II covered this distance during the third week at 9:00 o'clock in the morning in the first set, and at 6:00 o'clock in the afternoon in the third set. From the fourth to the twelfth week, the chicks in both lots were in any of the various zones at the different hours of observation in all of the three sets, except at 6:00 o'clock in the morning and at 6:00 o'clock in the afternoon in the first set.

The apparent lack of uniformity of the figures in the various zones in both lots during the various hours of observation was probably due to the habit of the birds to group themselves together, especially when in the shade. This tendency was observed among the chicks in lot II as early as the third week. The majority of the birds outside the house at the different hours of the day stayed in the first zone, or within a 3-meter distance

from the house. This is probably due to the fact that mash feed and drinking water were made available to the chicks in this zone at all hours of the day.

It was also observed that before the fourth week in the second and third sets, the chicks in both lots traveled farther at 6:00 and 9:00 o'clock in the morning and at 6:00 o'clock in the afternoon than at 12:00 o'clock noon and at 3:00 o'clock in the afternoon. After the fourth week, the chicks were in the farthest zone even during the hottest parts of the day. These chicks remained, however, in the shade. Since shady shrubs were distributed in the various zones, the chicks sought for cover in the different zones when it rained.

It was further observed that at 6:00 o'clock in the morning during the first set, zone 6 was reached only during the eighth week by the chicks in lot II and during the ninth week by those in lot I. At 6:00 o'clock in the afternoon in the same set, the chicks in lot II reached zone 6 on the fifth week and those in lot I on the eighth week. The chicks in lot II traveled farther than those in lot I during those weeks when there was lack of sufficient daylight in the first set. Very few chicks in both lots in the first set traveled far away from the house during those weeks when there was insufficient daylight at 6:00 o'clock in the morning and at 6:00 o'clock in the afternoon. In the second and third sets when there was sufficient daylight at those hours, zone 6 was reached by the chicks in both lots at this time before the fifth week, and even as early as the third week. These observations indicate that chicks would not go very far from the house while it was still dark in the morning, and they would go near the house as soon as the sun approached the horizon in the afternoon.

Staying outside the house. During the first week in the second and third sets, about 43 per cent of the chicks in lot I and about 38 per cent of those in lot II were outside the house at 6:00 o'clock in the morning; about 60 per cent in lot I and 50 per cent in lot II at 9:00 o'clock in the morning; about 14 per cent in lot I and 10 per cent in lot II at 12:00 o'clock noon; about 17 per cent in lot I and 14 per cent in lot II at 3:00 o'clock in the afternoon; and about 38 per cent in lot I and 44 per cent in lot II at 6:00 o'clock in the afternoon. Except at 6:00 o'clock in the afternoon, there were more chicks outside the house in lot I than in lot II during the first week, due probably to the influence of the hen present in lot I. There was a gradual increase in the number of birds outside the house at each hour of observation in both lots up to the fourth week. It is also apparent that there was a slightly larger percentage of chicks outside the house in lot I than in lot II up to the time the chicks were weaned by the hen, except at 6:00 o'clock in the afternoon. The hen in lot I was oftentimes sitting with her chicks at this hour, as it was getting dark and chilly. Very few chicks were outside the house

at 6:00 o'clock in the morning before the ninth week and at 6:00 o'clock in the afternoon before the seventh week in the first set, probably because it was not bright enough for them to go around. After those weeks of insufficient daylight at 6:00 o'clock in the morning and at 6:00 o'clock in the afternoon, the percentage of the birds staying outside the house at the same hours of observation in all three sets was almost the same, except during the eleventh and twelfth weeks in the third set. Apparently, there was enough daylight at those hours to enable the birds to move about. This observation indicates that chicks would go out as soon as they see light in the morning. The caretaker, therefore, should get up and open the doors of the brooder house as early as light would permit so that the birds could go out freely.

Except during the first set, more birds were outside the house at 6:00 and 9:00 o'clock in the morning, and at 6:00 o'clock in the afternoon than at the other hours of observation. Few birds were outside the house at 12:00 o'clock noon and at 3:00 o'clock in the afternoon, or during the hottest parts of the day before the eighth week. At these times most of the chicks stayed under the house, for it was cooler there than inside. After the eighth week or during the latter weeks, the majority of the chicks preferred to stay outside in the shade even during the hottest parts of the day. Except when the rain was relatively heavy and continuous, quite a large number of birds were outside during rainy days than during hot days. The percentage of birds outside the house was relatively higher in the third set when there was greater rainfall than in the first and second sets.

Feeding. Except in the first set, a larger percentage of birds were feeding in the mash troughs at 6:00 and 9:00 o'clock in the morning and at 6:00 o'clock in the afternoon than during the other hours of observation. Due to insufficient daylight, few birds before the seventh week were feeding at 6:00 o'clock in the morning and at 6:00 o'clock in the afternoon in the first set.

During the first set, about 13 per cent of the chicks in lot I and about 11 per cent in lot II were feeding at 6:00 and 9:00 o'clock in the morning and at 6:00 o'clock in the afternoon. At 12:00 o'clock noon and at 3:00 o'clock in the afternoon, only about 4 per cent of the chicks in lot I and about 2 per cent in lot II were feeding. Apparently, there was a lower percentage in lot II than in lot I during the first week at all hours of observation. But from the second to the fifth week, a slightly larger percentage of the chicks feeding was observed in lot II than in lot I, owing to the fact that the hen in lot I wandered from the brooder house most of the time. There seemed to be no marked changes in the number of birds feeding from the second to the twelfth week in the second and third sets for both lots at each hour of observation. Few birds were feeding during the hotter

parts of the day at 12:00 o'clock noon and at 3:00 o'clock in the afternoon because there were few birds that went out at these times. During cloudy or rainy days when it was not so hot, a large number of birds were feeding even at these hours.

It had been observed also that even if it was still dark early in the morning, some birds were already feeding in the mash troughs. In the late afternoon, some birds kept on feeding as long as they could see. This observation suggests that mash hoppers should be kept open and accessible to the birds at all times. The biggest number of chicks feeding in the mash troughs at one time was 83 per cent of the flock at 6:00 o'clock in the morning during the fourth week, and 71 per cent at 9:00 o'clock in the morning during the eighth week, all in lot I.

Drinking. There was a fairly uniform distribution of birds drinking in the watering troughs during the various hours of observation in all of the three sets. There was no marked difference between the two lots in the percentage of birds drinking, nor was there any between the different ages of the birds. While the distribution was about the same in the different hours of observation, it must be recalled that few birds would go out at 12:00 o'clock noon and at 3:00 o'clock in the afternoon. Evidently, a proportionately larger number of the birds going out were drinking at these hours, when it was relatively hotter than the other hours of observation. This points out again the necessity of having drinking water available to the birds at all times, especially during the hotter parts of the day. Fewer birds were drinking during the cooler hours, and when there was rain. The biggest number of chicks drinking at one time was about 18 per cent of the flock at 3:00 o'clock in the afternoon during the fourth week, and about 21 per cent at 3:00 o'clock in the afternoon during the eighth week; both percentages were observed in lot II.

Idling. Except in the first set, more birds were idling at 6:00 and 9:00 o'clock in the morning and at 6:00 o'clock in the afternoon than at the other hours of observation. Most of these birds at these hours were walking around or standing about with apparently no purpose in view. A slightly larger number of birds in lot II than in lot I were idling from the first week to the fourth week. Because of the absence of a hen, the chicks in lot II were more dispersed than those in lot I, especially during the first three weeks. After the fourth week, the same tendency was observed in both lots. A relatively smaller percentage could be observed at 12:00 o'clock noon and at 3:00 o'clock in the afternoon than at the other times of observation because of the fewer birds that went out at those times. Similarly, more birds were idling when there was slight rain than when the weather was too hot for comfort. The percentage of birds idling ranged from 1.6 per cent in lot I during the third week at 12:00 o'clock noon to 26.4 per cent in lot II during the twelfth week at 6:00 o'clock in the afternoon.

Scratching and picking. Except in the first set, more birds were scratching and picking at 6:00 o'clock and 9:00 o'clock in the morning and at 6:00 o'clock in the afternoon than at the other hours of observation. Like the number observed in idling, fewer birds were scratching and picking at 12:00 o'clock noon and at 3:00 o'clock in the afternoon than during the cooler parts of the day, and on hot days than on rainy days. Before the chicks had been weaned by the hen in lot I, a larger percentage of the birds engaged in this activity in lot I than in lot II, probably because of the influence of the hen in the former lot. After weaning time, practically the same tendency was observed in both lots. There was also a slightly higher percentage of birds scratching and picking in the second and third sets after the fourth week than in the first set. This was probably because after the fourth week in the second set, the advent of the rainy season afforded a better growth of forage and abundance of worms which the chicks could scratch and pick up. The biggest number of birds scratching and picking was 32.8 per cent in lot II during the ninth week at 6:00 o'clock in the morning. Although the feeds were available to the birds at all times in the mash troughs during the day, a considerable number of birds would still be scratching and picking in the yards at all hours of the day. Undoubtedly, chicks need enough space where they can scratch and pick up whatever they want to.

Running around. More birds were running around at 6:00 and 9:00 o'clock in the morning and at 6:00 o'clock in the afternoon than at the other hours of observation. The percentage in lot I was slightly higher than that in lot II up to the sixth week. This may be attributed to the fact that in the wanderings of the hen in lot I, the chicks left behind would run or fly to overtake the hen. There were few birds running around in both lots after the sixth week. This apparently shows that as the birds grow older and heavier, they tend to be less active. It was also observed that fewer birds were running around at 12:00 o'clock noon and at 3:00 o'clock in the afternoon than at the other hours of observation. The biggest number of birds running around was 11.9 per cent during the fifth week at 6:00 o'clock in the morning in lot I.

Staying in the shade. As expected, more birds were in the shade at 12:00 o'clock noon and at 3:00 o'clock in the afternoon, the hottest parts of the day, than at the other hours of observation, especially after the eighth week in all the three sets. Except when the rain was relatively heavy, most of the chicks preferred to stay in the shade than in the house. When it rained hard, some chicks stayed inside the house and others in the shade. When the rain abated, they went out to scratch or walk around. Evidently, the observations emphasize the need for ample shade in the yards to provide protection of the birds from the heat of the sun and from rain. Between the two lots and the different ages of the chicks, there was no marked difference in the percentage of birds resting in the shade. They were observed,

however, to be doing a number of activities, such as resting on branches of shrubs, or lying down and dusting themselves in the ground.

Other observations. After the chicks had been given to the hen, they appeared indifferent. This attitude made the hen peck at some of the stubborn ones. Later on, the chicks learned to follow and obey the hen. The hen proved an asset, especially in teaching the chicks to feed and scratch and in safeguarding them against the attacks of hawks and other animals of prey.

SUMMARY AND CONCLUSION

1. The chicks began to go out on the second day. The majority of the birds that went outside the house during the first week were within a 3-meter radius from it. On the second week, however, the naturally brooded chicks reached beyond the radius of 15 meters from the house, while the artificially brooded chicks reached beyond this radius only during the third week.

2. During the period before the hen had weaned her chicks, a larger percentage of them was seen outside the house than those in the artificially brooded lot. During the same period, the chicks in lot I covered a range wider than that covered by those of lot II.

3. In both lots, more birds were outside the house at 6:00 and 9:00 o'clock in the morning and at 6:00 o'clock in the afternoon than at 12:00 o'clock noon and 3:00 o'clock in the afternoon. More birds were outside the house during rainy days than during hot days.

4. More birds were feeding in the mash troughs, idling about, scratching and picking, and running around at 6:00 and 9:00 o'clock in the morning and at 6:00 o'clock in the afternoon than during the other hours of observation.

5. Most of the birds outside the house at 12:00 o'clock noon and at 3:00 o'clock in the afternoon were in the shade. The observations emphasize the need for ample shade in the yards to provide protection of the birds from the heat of the sun and from the rain.

6. More of the birds outside the house were drinking at 12:00 o'clock noon and at 3:00 o'clock in the afternoon than at the other hours of observation.

7. A considerably large number of birds outside the house at the different hours of the day were feeding in the mash troughs as long as there was sufficient light for them to see.

8. The results of this study show that growing Los Baños Cantonese chicks will not wander very far from the brooder house if feed, water, green grass, and shade are made available to the birds near the house at all times during the day.

A STUDY OF THE EFFECTS OF DIFFERENT AMOUNTS OF WATER ON SURFACE AND SUBSURFACE IRRIGATION OF LETTUCE[1]

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WITH FIVE TEXT FIGURES

In the Philippines, surface irrigation mainly by hand sprinkling helps produce truck crops on a commercial scale. Subsurface irrigation, commonly known as subirrigation, which is either the control of the water table in lands of high water table or the supplying of moisture by means of underground conduits, has never been extensively used and the water requirement and the method of irrigating truck crops, particularly lettuce, is still wanting in the Philippines. While subirrigation necessitates subsurface installations for irrigation, it has the advantages of reducing evaporation, preventing baking of surface soil, and eliminating surface distribution system.

Beattie (1929) stated that lettuce grown in the eastern or humid regions of the United States requires from 5 to 8 inches (12.70 to 20.32 cm.) of rainfall or its equivalent in irrigation to produce a spring crop. The amount of water needed was somewhat dependent upon the character of the soil, the percentage of cloudy weather, and the prevalence of winds. Etcheverry and Harding (1933) said that the total water requirement for truck crops is generally from 1 to 1½ acre-foot per acre (30 to 45 hectare-centimeter per hectare) for perennials or double-cropping annuals. Schwalen and Wharton (1930) found that lettuce irrigation in Arizona gave favorable results when the highest total amount of irrigation water applied was 25.6 inches (65 cm.) plus 2.54 inches (6.45 cm.) precipitation.

As regards the method of irrigation used, Peralta (1921) noted that the constant supplying of water seemed to make the water more available to the plant. Beattie (1929) stated that subirrigation supplements the natural rainfall in the eastern lettuce-growing section of the United States. Israelsen (1932) asserted that impervious subsoil at a depth of 6 feet or more, porous loam or sandy loam surface soil, uniform topographic condition, and moderate slopes favor subirrigation.

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The wide variations in the method of irrigation and the quantity of water applied by different growers suggested the need for experimental work (a) to determine the amount of water most effective in the raising of lettuce in the locality and (b) to compare the effects of surface and subsurface methods of applying irrigation water. This study was performed in the Department of Agricultural Engineering and Department of Soils, College of Agriculture, College, Laguna from November, 1947 to October, 1948.

MATERIALS AND METHODS

Soil. Los Baños clay loam, medium phase, taken from a rolling land of the U.P. Rural High School reservation on the way to the coffee plantation of the College, was used in this experiment. The land vegetated with a fairly growing *Calopogonium* sp. The surface soil is reddish brown and about 18 cm. deep. It pulverizes easily when dry; when wet, it is sticky and plastic. According to Aristorenas (1937), this soil has a maximum water-holding capacity of 62 per cent, a pore space of 61 per cent, a volume expansion of 0.26 per cent, a specific gravity of 1.27, pH of 7.38, and contains 0.06 per cent K_2O. Aquino and Orig (1941) found it to contain 0.0031 per cent nitrogen, 0.0107 per cent P_2O_5, and 0.0313 per cent K_2O soluble in 1 per cent citric acid.

Enough soil to last three plantings was gathered from 12 to 15 centimeters of the surface, thoroughly mixed, and hauled to a concrete tank behind the Agricultural Engineering building where it was stored. A composite sample was taken and its water-holding capacity, both on air-dry and on oven-dry bases, was determined in the Department of Soils. Six trials showed an average water-holding capacity of 50.18 per cent based on air-dry sample, while three trials on oven-dry basis gave 65.4 per cent, which was only 3.4 per cent higher than the finding of Aristorenas (1937).

After drying in the air, the soil was pulverized and screened through a 7-mm. sieve in order to equalize the granulation. Equal weights of the soil were placed in 100 one-gallon tin cans. A layer of pea-size gravel was placed at the bottom of each can to prevent future clogging of the holes. From this number, 10 groups of 10 cans each were classified at random. Surface irrigation was used in five groups randomly assigned to lot I, and subirrigation for the rest in lot II. Each group of tin cans was placed in a longitudinally divided gasoline drum which collected the percolated water in lot I and the irrigation water in lot II. Each trough for lot I had a hole at one end for draining the percolated water.

Planting materials. Seedlings of the nonheading variety of lettuce of the same age, and apparently of the same size and vigor were planted, one in each can. For five days the seedlings were all watered overhead so as to stabilize the root systems and to insure growth. Lettuce was chosen because

it can be grown to full size in the culture cans or pots. It is one of our most important truck crops and has been found to be readily responsive to different soil moisture contents.

Control of water. For the first planting, lot I and lot II were each divided into five groups or cultures. Each plant in culture 1 of both lots received an amount of water equivalent to 40 per cent of the water-holding capacity (air-dry basis) of the soil in each can. Since the contents of one can when thoroughly air-dried weighed 2.10 kgm. and the water-holding capacity of the soil was 50.18 per cent, the amount of water equivalent to 40 per cent of the water-holding capacity was 0.42 kgm. or 0.42 liter. Culture 2 received 60 per cent or 0.63 liter of water per can; culture 3, 80 per cent or 0.84 liter; culture 4, 100 per cent or 1.05 liters; and culture 5, 120 per cent or 1.26 liters. The calculation of water needed by each plant was based on the air-dry weight of the soil, inasmuch as the moisture present in the soil after air-drying was no longer available to the plants.

The application of water by surface irrigation to the plants in lot I was controlled by using painted tin cans provided with an equal number and size of perforations to simulate a hand sprinkler. The cans were suspended above the plants from a pole, and with the use of calibrated tin cans the desired amount of water was poured into them. Thus, the velocity of water dropping into the plants was, more or less, equalized in each culture.

In the subirrigated lot the water level was first set to a height just enough to saturate the pebbles placed at the bottom of each can. Then with the use of the calibrated tin cans the desired amount of water was poured directly into the halved gasoline-drum trough. In culture 1, for example, 4.20 liters of water (0.42 liters $\times$ 10) was poured to supply the 10 plants in the culture. A marker was placed to indicate the level of water. Every afternoon between 4:30 P. M. and 6:00 P. M., the water level was raised to this mark. The water in each container was totally drained twice a week in order to avoid the multiplication of water-inhabiting microörganisms.

RESULTS AND DISCUSSION

First planting. The plants in lot II (subirrigation) appeared more vigorous than those in lot I (surface irrigation), three weeks after transplanting. Six weeks after transplanting two plants showed signs of maturity (flowering) in lot I, and one plant each in culture 1 (40 per cent) and culture 4 (100 per cent), while in lot II there were four: three in culture 2 (60 per cent) and one in culture 4 (100 per cent).

On March 4, 1948, 50 days after transplanting, the plants were harvested and weighed. Table 1 shows the average weights of the lettuce plants from each culture. The analysis of variance proved that subsurface

irrigation (lot II) gave a significantly better result than the overhead or sprinkler method of irrigation (lot I). It also shows that there is a significant difference as a result of the variation of the amount of irrigation water applied. As shown in figure 1, the yield decreased as the amount of water applied became excessive.

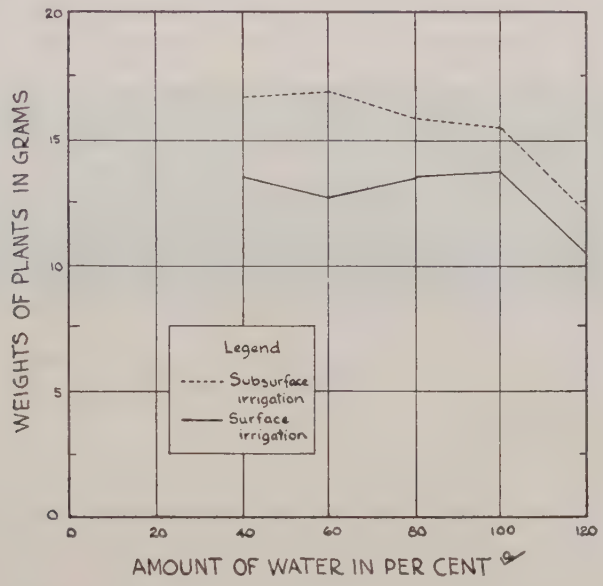

Fig. 1.—Average weights of lettuce plants from the first planting; precipitation, 54.23 millimeters.

Table 2 shows the average weights of roots of the same plants. As could be expected, the subirrigated plants produced a significantly heavier root system. There was also an apparent increase in the development of roots as the water applied was decreased. It is also shown in table 1 that the subirrigated plants produced longer roots. It was noted during the experiment that the roots of these plants had the tendency to penetrate deeply toward the source of water under the soil.

Weather observations during the period were taken from the local weather observation station, the rain gauge of which was about 150 meters from the place of the experiment. These are shown in table 5. In addition to the amount of irrigation water applied (table 4), a total precipitation of 54.23 mm. occurring in 10 days from January 29 to February 28, 1948, was noted. Most of the rain fell on January 31, 1948, with the precipitation amounting to 41.2 mm.

During the first planting no plant was attacked by any insect pest or disease.

Second planting. In the second and third plantings one more set of culture was added to each lot, making a total of six cultures to a lot. The cultures were treated as follows: culture 1 received water equivalent to 10 per cent of the water-holding capacity of the soil or 105 ml. for every irrigation period; culture 2, 20 per cent; culture 3, 40 per cent; culture 4, 60 per cent; culture 5, 80 per cent; and culture 6, 100 per cent (fig. 2). The total amount of water applied in each culture is shown in table 4.

Fig. 2.—The appearance, 50 days after planting, of lettuce plants treated with different amounts of water: left, 6 cans, surface irrigated and right, 6 cans subsurface irrigated. The percentages shown here refer to the amount of water in terms of the water-holding capacity of the soil used (air-dry basis).

Similarly as in the first planting, the plants in lot II began to show more vigor than those in the other lot during the third week after planting. The rain during this period was lighter than that of the first period, and it was more evenly distributed (table 5). Most of the rain fell at the time when the plants were at their best growing stage. The marked increase in vigor might have been caused by such condition, or by the washing off of the dust which accumulated at the time when the supply of moisture was coming solely from below by means of capillarity and interfered with the functioning of the stomatal pores.

At the end of the second week, the plants in culture I in both lots were noticeably retarded in growth. This showed the insufficiency of the amount of water applied to them. At the beginning of the sixth week after planting, most of the more vigorous plants in both lots showed signs of maturity. At the end of the same week, one plant each in cultures 2 and 3 and one in culture 2 of lot II flowered. On May 5, 1948, or 51 days after transplanting, the plants were harvested and weighed. The comparative effects of the varying amounts of water in the two methods of irrigation are given in table 1. The analysis of variance shows that the variation in the amount of irrigation water and the method of application produced significant differences. Based on the computed least significant mean difference (L.S. M.D.) of 5.75 grams, it can be deduced that in both lots the difference in weights of the lettuce plants between culture 1 and the rest of the cultures was very highly significant. From cultures 2 to 6, inclusive, the differences

were generally insignificant, except between culture 6 and either culture 2 or 3 in lot I, where the difference was slightly significant. The lower weight of plants in culture 6 of lot I may be attributed to more washing and leaching effect of the overhead irrigation on the fertility of the soil as the amount of water was increased. As graphically shown in figure 3, however, plants in both lots, as in the first planting, showed a tendency to decrease in yield as the amount of water was increased beyond 80 per cent of the water-holding capacity of the soil.

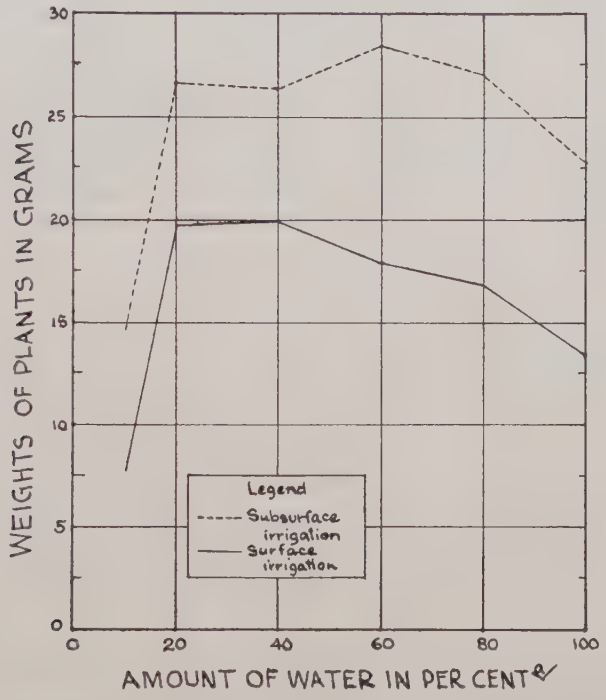

Fig. 3.—Average weights of lettuce plants from the second planting; precipitation, 37.10 millimeters.

Again, as in the first planting, the differences in the weights and lengths of roots were highly significant in favor of the subirrigated plants (tables 2 and 3). The analysis of variance also showed that the variation of water in both lots caused significant differences in the root development of the plants.

As can be noted in table 1, the yield of the lettuce plants during the second planting was considerably greater than that of the first planting. The favorable weather and even distribution of rainfall during the second planting proved beneficial. The seedlings used in this plant-

ing were more vigorous, but a random attack of the larvae of *Plusia chalcytes* Esper.[2] was noted. This insect pest, however, was not able to do much damage, for it was easily checked by constant hand picking.

Third planting. Eighteen-day-old seedlings, sown and thinned in plots, were transplanted on May 23, 1948, for the third planting. As shown in table 5, this crop was overtaken by constantly heavy rains such that only 25 applications of irrigation water were needed (table 4). Though the plants grew taller than those in the first and second plantings, the production of leaves was very slow. The leaves were generally very much inferior in size and quality. The other cultures showed more uniform maturity.

The plants were harvested 50 days after transplanting. The results are shown in table 1. The analysis of variance shows that under the conditions during the third planting, the experiment gave no significant results. However, when graphically shown (fig. 4), the tendency of the yield curves in both lots is similar to those of the second planting,

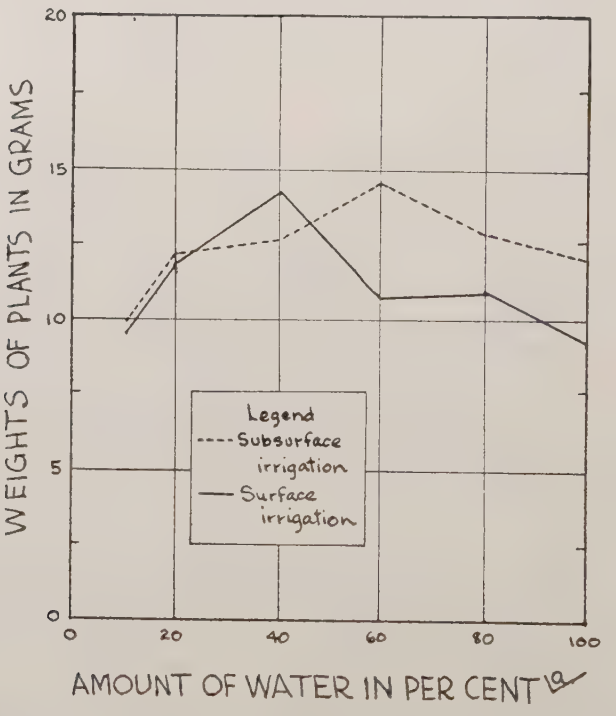

Fig. 4.—Average weights of lettuce plants from the third planting; precipitation, 254 millimeters.

[2]The insect was identified in the Department of Entomology.

and the subirrigated plants had slightly more vegetative growth than the surface irrigated ones. Subirrigation produced significantly more and longer roots.

No insect pest or disease was noted during the third planting.

Water requirement of lettuce. According to Etcheverry and Harding (1933), the water requirement of any irrigated crop is the amount of water required for the production of the crop. Under the conditions prevailing during the experiment the writers noted that the water requirement of lettuce can be satisfied if irrigation water corresponding to 20 per cent up to 80 per cent of the water-holding capacity (air-dry basis) of Los Baños clay loam is applied. The economical water requirement ranges from 20 to 40 per cent. The equivalent heights of water applied as shown in table 4 are: first planting, 100.22 cm.; second planting, 44.14 cm. to 88.29 cm.; and third planting, 29.83 cm. to 59.60 cm. This finding corroborates that of Schwalen and Wharton (1930) in Arizona. They found that the maintenance of a high uniform soil moisture content at or above the water-holding capacity is favorable for production of heavy lettuce heads. A soil moisture content slightly below it, however, does not materially reduce the head weight. In the present experiment percolated water began to flow when water equivalent to 60 per cent of the water-holding capacity was added to the soil, showing that the amount was more than enough to saturate the soil.

It was also found that water equivalent to 10 per cent of the water-holding capacity of the soil (air-dry basis) was insufficient for the plant needs. Although the plants treated with this amount were able to survive, their respective weights at harvest time were very significantly lower than those of other cultures. They wilted during daytime and showed signs of stunted growth.

Method of irrigation. The results of the experiment indicate that subirrigation is better than overhead sprinkling. This finding, in some way, conforms with those of Daniel (1916), who found that several garden plants supplied with water permitted to percolate continuously but very slowly through cotton or wool to the roots developed more rapidly than plants spasmodically watered in the ordinary way. Another disadvantage of the overhead surface-irrigation method lies in the fact that after each watering, the plant must pass through a cycle from an excessive water supply to an inadequate water supply—a condition which lasts until the next watering. Therefore, during part of the cycle, the growth of the plants must have been retarded.

All soils, however, may not respond equally well to subirrigation. The ideal conditions according to Lewis (1943) are as follows: (1) naturally high water table or an impervious subsoil; (2) soil and water supply reasonably

free of soluble salts; (3) natural precipitation sufficient at some time during the year to leach the soluble salts accumulated during the irrigation season down from the surface; and (4) a smooth and nearly level land surface.

Another advantage of subsurface irrigation is that it requires less cultivation. In this experiment every time the weekly cultivation was done, lot II did not seem to need it. The surface of the soil was always porous and well aerated while that of lot I, surface irrigated, became baked and hardened after two or three waterings.

Root development. Subirrigation induced better root development; the plants generally produced heavier and longer roots than those watered by overhead sprinkling. Though the variation of the degree of root development of the plants in each culture was generally significant, no specific culture could be pointed out to be the best. The degree of the development of the roots, judging from their weights and lengths, however, seemed to follow that of the yield curve, but a more abrupt decrease was noted as the amount of water became excessive. Representative plants from each culture showing the roots are shown in figure 5.

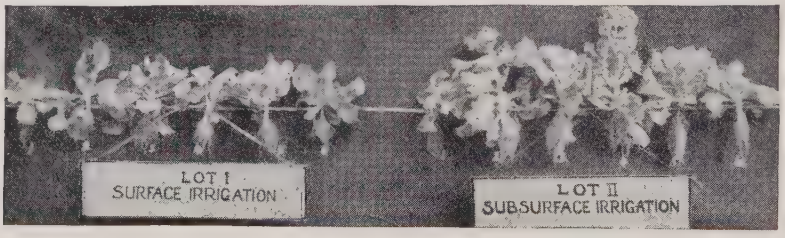

Fig. 5.—The appearance 50 days after planting of representative plants from the different cultures receiving varying amounts of water. In both lots, numbers 1, 2, 3, 4, 5, and 6 received water equivalent to 10, 20, 40, 60, 80, and 100 per cent, respectively, of the water-holding capacity of the soil (air-dry basis).

Maturity. The maturity of the plants was not localized such that it was hard to arrive at any definite conclusion. In the first and second plantings, however, the earliest signs of maturity were noted in the cultures where the amount of water applied was previously classified as sufficient.

SUMMARY

1. The best yield of lettuce in unfertilized Los Baños clay loam was obtained when the plants were supplied with water not lower than 20 per cent of the water-holding capacity (air-dry basis) of the soil.

2. The yield had the tendency to decrease when the water applied exceeded 80 per cent.

3. The most economical amount of water in surface and subsurface irrigation methods was between 20 and 40 per cent of the water-holding capacity of the soil.

4. Higher yield and more vigorous plants were produced with subirrigation than with surface irrigation.

5. Subirrigated lettuce plants produced better developed roots.

6. Assuming that there was no rainfall and the frequency of irrigation was 42 days (the best age for harvesting lettuce found in the experiment), the total depth of water most economical for raising lettuce was from 50 to 100 centimeters.

7. Subirrigation requires less frequent cultivation than the overhead surface irrigation method.

8. The loss of moisture through evaporation from the surface of the ground was less in subirrigated plots than in surface irrigated ones.

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TABLE 1

Average weights of lettuce plants grown in unfertilized Los Baños clay loam treated with varying amounts of water in two methods of irrigation[a]

LOT NO.	IRRIGATION METHOD USED	NO. OF PLANTS	CULTURE NUMBER 1	2	3	4	5	6	MEAN
			grams	*grams*	*grams*	*grams*	*grams*	*grams*	
			FIRST PLANTING						
I	Surface	10	13.45	12.75	13.42	13.64	10.62		12.77
II	Subsurface	10	16.75	16.90	15.74	15.41	12.16		15.39
			SECOND PLANTING						
I	Surface	10	7.54	19.77	19.91	17.85	16.93	13.32	15.88
II	Subsurface	10	14.49	26.65	26.28	28.17	27.15	22.60	24.21
			THIRD PLANTING						
I	Surface	10	9.51	11.79	14.06	10.66	10.74	9.24	11.00
II	Subsurface	10	9.86	12.22	12.62	14.63	12.96	12.08	12.39

[a]Total precipitation during the first, second, and third plantings were 54.23 mm., 37.10 mm. and 254 mm., respectively.

Analysis of variance

SOURCES OF VARIATION	DF	SUM OF SQUARES	VARIANCE	COMPUTED F-VALUE	TABULAR F-VALUE .05	.01
	FIRST PLANTING					
Total	99	1206.30				
Lot treatment	1	171.09	171.09	18.60	3.95	6.93
Culture treatment	4	185.60	46.40	5.16	2.47	3.53
Interaction	4	23.90	5.90	0.56	2.47	3.53
Error	90	825.71	9.17			
	SECOND PLANTING					
Total	119	9099.37				
Lot treatment	1	2080.86	2080.86	49.05	3.93	6.88
Culture treatment	5	2356.62	471.32	11.11	2.30	3.19
Interaction	5	80.41	16.08	0.37	2.30	3.19
Error	108	4581.48	42.42			
	THIRD PLANTING					
Total	119	2974.51				
Lot treatment	1	78.38	78.38	3.24	3.93	6.88
Culture treatment	5	176.79	35.56	1.44	2.30	3.19
Interaction	5	77.30	15.46	0.63	2.30	3.19
Error	108	2642.04	24.46			

L.S.M.D.—2.64 first planting, 5.75 second planting, and 4.38 third planting, respectively.

TABLE 2
Average weights of roots of the same plants as in table 1

LOT NO.	IRRIGATION METHOD USED	NO. OF PLANTS	CULTURE NUMBER 1	2	3	4	5	6	MEAN
			grams	*grams*	*grams*	*grams*	*grams*	*grams*	
			FIRST PLANTING						
I	Surface	10	4.70	3.85	3.87	3.71	3.16		3.85
II	Subsurface	10	7.46	6.89	6.37	6.83	4.96		6.50
			SECOND PLANTING						
I	Surface	10	2.00	4.88	3.96	3.39	3.73	2.75	3.46
II	Subsurface	10	3.39	9.84	8.23	10.53	11.75	4.73	8.71
			THIRD PLANTING						
I	Surface	10	2.34	2.19	2.28	2.05	1.89	1.49	2.04
II	Subsurface	10	3.40	4.81	4.86	4.32	4.40	4.49	4.38

Analysis of variance

SOURCES OF VARIATION	DF	SUM OF SQUARES	VARIANCE	COMPUTED F-VALUE	TABULAR F-VALUE .05	.01
	FIRST PLANTING					
Total	99	364.86				
Lot treatment	1	174.77	174.77	110.61	3.95	6.93
Culture treatment	4	42.24	10.56	6.68	2.47	3.53
Interaction	4	5.65	1.41	0.89	2.47	3.53
Error	90	142.20	1.58			
	SECOND PLANTING					
Total	119	1921.76				
Lot treatment	1	642.19	642.19	103.24	3.93	6.88
Culture treatment	5	430.14	86.02	13.81	2.30	3.19
Interaction	5	177.75	35.55	5.71	2.30	3.19
Error	108	671.68	6.22			
	THIRD PLANTING					
Total	119	454.17				
Lot treatment	1	164.27	164.27	65.44	3.93	6.88
Culture treatment	5	7.65	1.53	1.61	2.30	3.19
Interaction	5	11.22	2.24	0.89	2.30	3.19
Error	108	271.03	2.51			

L.S.M.D. — 1.12 first planting, 2.20 second planting, and 1.39 third planting, respectively.

TABLE 3

Average lengths of roots of the same plants as in table 1

LOT NO.	IRRIGATION METHOD USED	NO. OF PLANTS	CULTURE NUMBER						MEAN
			1	2	3	4	5	6	
			cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
			FIRST PLANTING						
I	Surface	10	11.55	9.54	9.45	8.70	8.64		9.54
II	Subsurface	10	14.94	14.14	12.25	12.35	12.29		13.94
			SECOND PLANTING						
I	Surface	10	6.85	7.45	7.40	7.05	6.35	6.30	6.90
II	Subsurface	10	7.80	11.25	10.10	11.71	11.09	10.02	10.32
			THIRD PLANTING						
I	Surface	10	7.30	7.69	9.10	9.20	7.98	7.33	8.10
II	Subsurface	10	10.42	11.99	11.76	10.43	10.43	10.00	10.83

Analysis of variance

SOURCES OF VARIATION	DF	SUM OF SQUARES	VARIANCE	COMPUTED F-VALUE	TABULAR F-VALUE	
					.05	.01
		FIRST PLANTING				
Total	99	614.28				
Lot treatment	1	327.25	327.25	175.94	3.95	6.93
Culture treatment	4	110.78	27.69	14.88	2.47	3.53
Interaction	4	8.43	2.10	1.13	2.47	3.53
Error	90	167.82	1.86			
		SECOND PLANTING				
Total	119	696.57				
Lot treatment	1	352.60	352.60	164.00	3.93	6.88
Culture treatment	5	60.52	12.10	5.62	2.30	3.19
Interaction	5	50.67	10.13	4.71	2.30	3.19
Error	108	232.78	2.15			
		THIRD PLANTING				
Total	119	411.29				
Lot treatment	1	224.95	224.95	210.23	3.93	6.88
Culture treatment	5	45.36	9.07	8.47	2.30	3.19
Interaction	5	24.77	4.95	4.62	2.30	3.19
Error	108	116.21	1.07			

L.S.M.D. — 1.21 first planting, 1.29 second planting, and 0.91 third planting, respectively.

TABLE 4

Total amount of water applied and seasonal precipitation in the three plantings of lettuce

PLANTING	FREQUENCY	AMOUNT OF WATER APPLIED IN BOTH LOTS							RAINFALL	
		10 per cent[a]	20 per cent	40 per cent	60 per cent	80 per cent	100 per cent	120 per cent	Total	Distribution
	days	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*days*
First	42	—	—	100.22	150.34	200.45	250.56	300.68	54.23	10
Second	37	22.07	44.14	88.29	132.44	176.59	220.74	—	37.10	13
Third	25	14.91	29.83	59.60	89.41	119.31	149.14	—	254.00	33

[a] Based on the water-holding capacity of the soil (air-dry sample).

TABLE 5[a]

Weather observations during the three successive plantings of lettuce

PLANTING	TEMPERATURE		AV. RELATIVE HUMIDITY	RAINFALL		CLOUDINESS
	Av. minimum	Av. maximum		Total	Distribution	
	°C	°C	*per cent*	*mm.*	*days*	*visibility*
First	21.4	28.1	76.7	54.23	10	7–8
Second	23.5	32.0	73.1	37.10	13	8
Third	24.2	32.3	84.7	254.00	33	8–9

[a]The data were taken from the weather station of the College of Agriculture.

MORPHOLOGY AND HEREDITY OF CARYOPSIS CHARACTERS IN INANGEL RICE[1]

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Of the Department of Agricultural Botany

WITH FOUR TEXT FIGURES

Inangel rice gets its name from the two long empty glumes which look like wings. It is an upland glutinous variety possessing grain characteristics the botanical behavior of which is not yet understood. The present study, which was performed in the Department of Agricultural Botany from July, 1947, to October, 1948, was undertaken in order to discover the botanical behavior of the caryopsis characters of Inangel rice and the heredity of such features in the first-filial-generation progeny.

Juliano and Aldama (1937) described the empty glumes of *Oryza sativa* as possessed with poorly developed vascular bundles at the thickest portion, the endosperm of the nuclear type and surrounded with a one- to five-layered aleurone layer, and the seed coat derived from the innermost epidermis of the inner integument.

Tablante[2] found on xenia on rice that the outer glume color was a monofactorial unit character, that the starchy endosperm was dominant over the glutinous endosperm, and that the pericarp color gave a monofactorial inheritance.

Varying modes of inheritance in different colored rice were given by Parnell, Ayyangar, and Ramiah (1917), Hector (1922), Thompstone (1915), and McKerral (1913).

MATERIALS AND PROCEDURE

The two varieties of rice used: Inangel and Fortuna

Inangel is an upland glutinous variety that has broad grains and straw-colored "wings" consisting of the conspicuously developed empty glumes. The pericarp is black or dark purple similar to that of the Pirurutong rice variety. The plant has broad, smooth, dark-green leaves. It matures in about 130 days.

Fortuna is a dual-purpose rice. When planted under upland conditions, it produces grains that are long and slender; when grown under low-

[1]Experiment Station Contribution No. 1531. Based on the thesis presented for graduation by the junior author October, 1948, with the degree of Bachelor of Science in Agriculture from the College of Agriculture.

[2]Tablante, N. B. Xenia and inheritance of glutinous endosperm in rice. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1946. Unpublished.)

land conditions, it produces long but wider and bigger grains. It has straw-colored glumes with purple pigmentation at the apical end, a white starchy endosperm, and green leaves. It matures in 135 days.

About 100 seeds of each variety which had been soaked in tap water for 24 hours were planted on July 8, 1947, on clay loam soil in gasoline drums cut crosswise. Five pots were used for each variety.

The seeds of the two varieties were planted 30 centimeters apart and were given practically the same upland conditions throughout the experiment. Whenever necessary the plants were watered liberally.

Technique of controlled pollination

Castration, or emasculation, of the flowers was performed very early in the morning at least two hours before dehiscence. The clip method of emasculation described by Mulimbayan (1935) and followed in this study consists of cutting with a pair of small scissors the upper one-fourth to one-third portion of the glumes of the unopened flower and then removing the anthers with a pair of forceps. Generally, the rice floret was emasculated a day after its appearance from the leaf sheath. Where the flowers were already open they were cut off. As many flowers as convenient were emasculated on each panicle; the very young ones and those that had not been emasculated were cut off.

To prevent contamination, each panicle was covered after emasculation with a cellophane bag. Artificial cross-pollination was made at the time of natural anthesis of the male parent, when the pollen is at its maximum viability.

Pollination was performed by dusting the pollen of a few newly opened flowers of the male parent variety over the plumose stigmas of emasculated flowers. Sometimes the pollen grains were gathered in a watch glass at the time of dehiscence and applied to the stigmas of the emasculated flowers with a pointed needle. The latter method was used frequently to enhance maximum supply of pollen.

A direct cross between Inangel and Fortuna was performed. The reciprocal cross was also made, but plants from the cross were accidentally destroyed during the course of the experiment.

Culture of the cross-pollinated grains and the parental types

Owing to the fact that the upper portion of the palea and lemma were cut off in emasculation, the upper part of the kernel which was exposed was smaller than the lower part which remained covered. This condition necessitated special care in the germination of the seeds. The hybrid seeds were germinated on a sand medium previously sterilized by heating. This medium was preferred to the nutrient solution because of the ease in its

preparation and handling during the operation. The sand was placed in porcelain tumblers and moistened with sterile water. The seeds were placed directly in the tumblers and allowed to germinate. Sterile water was frequently sprayed to insure the supply of moisture to the germinating seeds. On May 26, 1948, when the seedlings were about six to ten centimeters high, they were transferred to the culture pots, one plant to a hill.

In July, 1947, representative seeds from the parent varieties were soaked in water for 24 hours and then sown in separate culture pots and treated as in the first planting.

Care was taken to insure normal growth and development of the growing seedlings.

RESULTS AND DISCUSSION

Microscopic study of the empty glumes

The surface section of a young empty glume shows regularly distributed rows of elongated cells (fig. 1 upper left panel). These elongated cells have irregular walls (fig. 1 upper right panel), each imbedding a corrugated, spiraled content. The regularity in the distribution of the rows of cells is

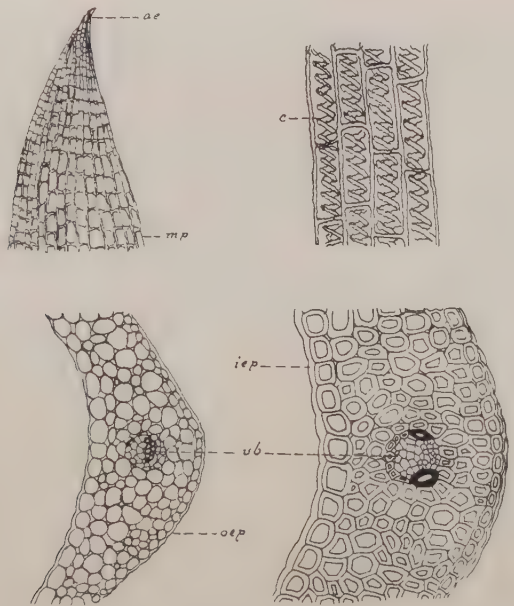

Fig. 1.—Upper left panel, surface section of a young empty glume, showing the almost regular distribution of the rows of cells; *ae*, apical end; *mp*, middle portion. ×270. Upper right panel, portion of the enlarged surface section of the young empty glume; *c*, cell content. ×430. Lower left panel, cross section of a very young empty glume long before anthesis, showing the poorly developed vascular bundle (*vb*); *oep*, outer epidermis. ×430. Lower right panel, cross section of a fully mature empty glume, showing the thick-walled cells; *iep*, inner epidermis; *vb*, vascular bundle. ×430.

in contrast to the shape of the cells at the apical end. The cells at the tip of the glume are very much smaller than those at the middle and at the base.

A cross section of a young empty glume from a spikelet long before the emergence of the inflorescence from the flag or last leaf (fig. 1 lower left panel) shows a single vascular bundle which is poorly developed. The bundle is imbedded in a parenchyma in the thickest central portion from where the glume thins out toward the margins. The mesophyll consists of rounded,'thin-walled cell. At the margins these cells may be one layer thick, but seven or less layers at the thickest portion of the glume where the vascular bundle is located. It is easily seen that the inner epidermis, or morphologically the upper epidermis, is composed of cells larger than the cells of the opposite layer. Such features in Inapostol rice were also described by Juliano and Aldama (1937).

The cells of the glume (fig. 1 lower right panel) become lignified as the grain matures, and even reach a state of hardness and brittleness. Practically all the walls of the cells thicken whether they are of the inner or outer epidermis, or of the mesophyll.

Caryopsis characters of Inangel

The "wings", or empty glumes. The lower and upper empty glumes are similar in size and in shape. They are about 6.60 millimeters long as compared with the 1.65 millimeters long in Inapostol rice reported by Juliano and Aldama (1937). They are nearly triangular to linear-lanceolate and markedly concave in shape. The concave sides are directed toward the axis of the spikelet. The glumes are soft and very light green when young, but this color deepens to light green during and after anthesis. They become straw-colored, hard, and brittle at maturity.

Lemma. This flower-bearing glume is pale green when young. It becomes straw-colored, highly silicified, tough, and brittle at maturity. It is boat-shaped and measures about 8 millimeters long and 4 millimeters wide. The cross section is V-shaped, with the margins curved inward as it clasps the palea (fig. 2), and is thickest in the middle portion, then thins out gradually toward the margins. This observation differs from that of Santos (1933), who reported that the lemma is of uniform thickness.

Palea. Another glume which is next to the lemma is the palea. These two glumes (lemma and palea) are very similar in structure, shape, and texture, although the palea is smaller than the lemma. Moreover, attached to the lower portion of the palea at its two margins are two lodicules (fig. 2). The observation of Schuster (1910) and of Weatherwax (1929) that these lodicules possess poorly developed vascular bundles and fuse with the palea was reported by Santos (1933) and then cited by Juliano and Aldama 1937).

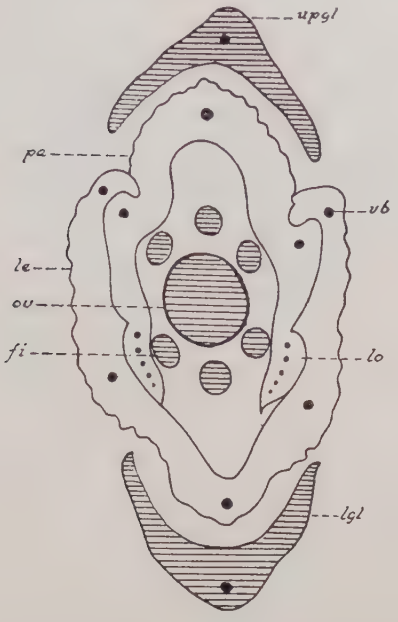

Fig. 2—Diagram of the cross section of the Inangel caryopsis, showing the relative positions of the three glumes as well as the two essential organs, the pistil and stamens; *fi*, filament; *le*, lemma; *lgl*, lower empty glume; *lo*, lodicule; *ov*, ovary; *pa*, palea; *upgl*, upper empty glume; *vb*, vascular bundle. ×39.

Rudimentary glumes. These are the rounded protuberances along the axis of the spikelet lying between the empty glumes (fig. 3).

Endosperm. The endosperm of Inangel is glutinous, opaque, and milky white like those of other commonly grown glutinous varieties.

Pericarp. Inangel rice possesses a highly pigmented black or dark-purple pericarp, a characteristic resembling that of the Pirurutong rice variety. Hence, Inangel is usually substituted for Pirurutong in some locally made cookies.

The inflorescence. At the earliest stage of booting, representative plants were gathered and cut longitudinally in order to expose the developing "head" (fig. 3 upper left panel). It was observed that the inflorescence develops at the fifth or sixth node. The last or the fifth internode is shorter than the preceding internodes and sometimes hardly visible to the naked eye at this stage. Oblong, rounded protuberances surround the rachis all over the surface; distinct differentiation follows as development continues (fig. 3 upper middle and upper right panel). At this stage, the "wings", or empty glumes, can be noted clearly. In the preceding stage (fig. 3 upper left panel) the glumes can be seen only under the microscope. The writers also found that the spikelets near the tip of the inflorescence develop first.

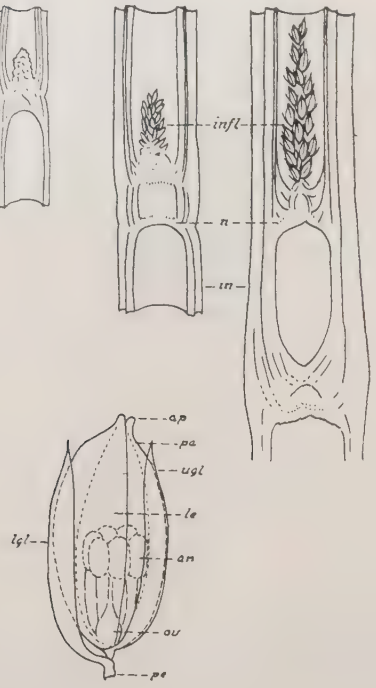

Fig. 3.—Upper left panel, the last node showing the head formation at the earliest stage of booting as seen by the naked eye. ×8. Upper middle panel, distinct head formation and elongation of the last internode (*in*); *infl*, inflorescence; *n*, node. ×10. Upper right panel, a distinctly differentiated inflorescence (*infl*); *in*, internode; *n*, node. ×5. Lower panel, a spikelet just before its emergence from the last flag; *an*, anther; *ap*, apiculus; *le*, lemma; *lgl*, lower empty glume; *ov*, ovary; *pa*, palea; *pe*, pedicel; *ugl*, upper empty glume. ×15.

Prior to emergence of the inflorescence from the flag or last leaf, the spikelet is light green, transparent, and pliable. The essential organs (fig. 3 lower panel), the whitish ovary and style, and the cream-yellow pigmented anthers are visible from the outside. During anthesis the glume opens at an angle of about 30 degrees, allowing the six bilobed, pollen-ladden anthers to protrude at the time of natural dehiscence. The glumes or scales on the spikelets do not open at the same time so that it takes about three or four days to pollinate or fertilize all the flowers. After fertilization the glumes close.

Comparison of caryopsis characters in the parent varieties and the F_1 progeny

Empty glumes. The first-filial progeny produced grains which were winged or possessed of a pair of conspicuously long empty glumes. In anatomical characters, these glumes resembled those of the maternal parent, Inangel, except that they were shorter. On the basis of the average lengths of the empty glumes of the two varieties (table 1a), there is a slight decrease

of 6.3 per cent of the F_1 progeny as compared with that of Inangel (maternal parent). The F_1 hybrids had glumes that averaged 149 per cent longer than those of the shorter empty-glumed parent and 36.6 per cent longer than the average of the two parents (table 1a).

Length of grain. A comparison of the average lengths of the grains of the F_1 plants and of the parents (Inangel and Fortuna) showed that the hybrids produced grains longer than either of the parental types. The averages of the length of the grains of the progeny were 4.1 per cent longer than those of the longer-grained parent (Fortuna) and 16.7 per cent longer than those of the shorter-grained parent (Inangel). Compared with the average of the two parents, the average of the hybrid exhibited an increase of 10.6 per cent (table 2a).

The differences in length of grain of the three varieties were highly significant (table 2b).

Breadth of grain. It may be noted in tables 3a and 3b that the F_1 grains assumed an intermediate breadth between the two parents. The F_1 grains were narrower than those of the maternal parent, the Inangel variety, but broader than the grains of the paternal variety, Fortuna. The hybrid caryopsis was wider than the Fortuna; the difference between their average breadths was 30.1 per cent. It was, however, narrower than Inangel; its average breadth was 3.94 per cent less. The average breadth of the hybrid was 10.6 per cent more than that of the two parents.

Highly significant differences in breadths were found among the different varieties studied, as shown in table 3b.

Notes on epistasis

Certain characters in the Inangel caryopsis suggest dominance, as far as the cross between Inangel and Fortuna is concerned. Such characters are the morphological features of the "wings", or the conspicuously developed empty glumes. The grains of the first-filial progeny of the cross (Inangel × Fortuna) possessed wings similar in shape, texture, and color to those of the maternal or pistillate parent (Inangel). Hence, it may be stated that this character of Inangel is dominant over the short-empty-glumed character of the paternal or staminate parent (Fortuna). This is similar to the results of Tablante[3], who found that the outer glume color of Pirurutong rice was a monofactorial unit character.

The F_1 hybrids produced grains intermediate in breadth between the grains of the two parental types, but in length the F_1 grains exceeded those of the parents. The first case suggests partial dominance while the latter case may be attributed to the phenomenon of heterosis, or hybrid vigor. During the early stage of grain development, the flower-bearing glumes (lemma and palea) of the hybrid were light green. On further devel-

[3] *Ibid.*

opment, particularly during the dough stage, a pinkish-purple tinge appeared at the apiculus of the grain and spread downward to a small surface of the lemma and palea. Such pigmentation was really expected inasmuch as one of the parents (Fortuna) possesses flower-bearing glumes with dark-purple apical ends. The pigmentation, however, did not persist but faded as the grains reached full maturity.

The resulting progeny produced dark-purple grains, another fact supporting the assumption of the dominance of the black pericarp of the Inangel caryopsis over the white pericarp of Fortuna grains. The endosperm

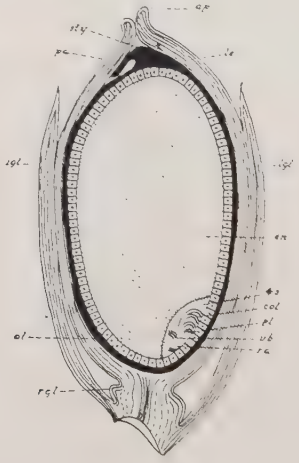

Fig. 4.—Diagram of the median longitudinal section of a ripened fruit; *al*, aleurone layer; *ap*, apiculus; *col*, coleoptile; *en*, endosperm; *le*, lemma; *lgl*, lower empty glume; *pa*, palea; *pl*, plumule; *ra*, radicle; *rgl*, rudimentary glume; *s*, scuttellum; *sty*, stylar end; *ugl*, upper empty glume; *vb*, vascular bundle. ×75.

of the F_1 grains was starchy, a feature derived from the starchy nature of the endosperm of the staminate parent, Fortuna. This again is suggestive of the dominance of the starchy endosperm over the glutinous endosperm. This mode of inheritance of the endosperm texture was reported by Tablante[4] in Fortuna rice.

Other features besides grain characters were also noted. The F_1 hybrid seeds germinated two days earlier than those of both parents. The hybrid had tillers ranging from 13 to 14, Inangel 11 to 12 tillers, and Fortuna 9 to 11 tillers—another improvement of the hybrid plant which is presumably due to heterosis. The F_1 plants flowered 5 days earlier than Inangel and 12 days earlier than Fortuna. They matured 7 days and 14 days earlier than Inangel and Fortuna, respectively.

[4] *Ibid.*

SUMMARY

1. The empty glumes of Inangel rice possess poorly developed vascular bundles centrally located at the thickest portions and imbedded in thin-walled mesophyll cells. The cells of the inner epidermis are larger than those of the outer epidermis. As the F_1 progeny possessed "wings", or empty glumes, it is presumed that the presence of this appendage of the caryopsis is dominant over its absence.

2. The breadth of the grains of the F_1 hybrid was intermediate between those of the two parents. The length of the grains of the F_1 progeny exceeded those of both parents, a case which may be attributed to heterosis.

3. The black pericarp of Inangel rice was dominant over that of Fortuna, but the starchy nature of the endosperm of the Fortuna variety was dominant over the glutinous endosperm of the Inangel.

4. The kernels of the F_1 progeny of the cross between Inangel and Fortuna germinated earlier than those of either parental types. Similarly, the F_1 plants developed and matured earlier than either of the parent plants.

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TABLE 1a

Lengths of the empty glumes of the three varieties

GRAIN NO.	VARIETY		
	Inangel	(Inangel x Fortuna) F_1	Fortuna
	mm.	*mm.*	*mm.*
1	8.0	6.0	3.0
2	7.5	7.5	3.0
3	7.0	6.5	3.0
4	7.0	8.0	3.0
5	8.0	8.5	3.5
6	6.0	7.0	3.0
7	6.5	5.5	2.0
8	6.5	7.0	2.0
9	6.5	6.5	3.0
10	7.5	7.0	3.0
11	6.5	6.5	2.0
12	7.5	6.5	2.5
13	7.0	6.5	2.5
14	6.5	6.5	2.5
15	7.0	7.0	3.0
16	8.0	6.5	3.0
17	8.0	6.5	3.0
18	7.0	6.5	2.5
19	7.5	7.0	3.0
20	7.0	6.5	2.5
21	6.5	6.0	2.0
22	7.50	5.5	2.5
23	7.0	6.5	2.5
24	6.0	6.0	2.0
25	6.5	6.0	2.5
Total.....	176.5	166.0	66.5
Mean.....	7.06	6.64	2.66

TABLE 1b

Analysis of variance of the lengths of the empty glumes of the three varieties

SOURCES OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F VALUE	
					.05	.01
Varieties.....	2	249.81	147.40	36.85	3.19	5.08
Individuals.....	24	4.42	0.19			
Error.....	48	19.36	0.40			
Total.....	74	318.59				

L.S.M.D. — 0.3598

TABLE 2a

Comparison of the lengths of the grains of the three varieties

GRAIN NO.	VARIETY		
	Inangel	(Inangel x Fortuna) F_1	Fortuna
	mm.	*mm.*	*mm*
1	8.0	11.0	10.0
2	9.0	9.5	10.0
3	8.0	9.5	9.5
4	8.5	10.0	9.5
5	9.5	10.0	10.5
6	9.0	9.0	10.0
7	7.5	9.0	9.0
8	9.0	8.5	9.0
9	8.0	9.0	9.5
10	8.5	9.5	10.0
11	9.0	9.5	9.0
12	8.5	9.5	9.5
13	8.0	10.5	9.0
14	8.0	10.0	9.0
15	8.5	10.0	10.0
16	8.5	10.5	9.5
17	8.0	9.5	10.0
18	8.0	9.0	9.0
19	8.0	11.0	9.0
20	8.0	9.5	9.0
21	8.5	9.5	8.5
22	7.0	8.5	9.5
23	8.0	10.0	9.0
24	7.5	10.5	8.0
25	8.0	11.0	9.0
Total.....	206.5	243.5	234.0
Mean.....	8.26	9.74	9.36

TABLE 2b

Analysis of variance of the lengths of the grains of the three varieties

SOURCES OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F VALUE	
					.05	.01
Varieties.....	2	29.54	14.77	41.03	3.19	5.08
Individuals.....	24	10.58	0.44	1.23	1.74	2.20
Error.....	48	17.30	0.36			
Total.....	74	57.42				

L.S.M.D. — 0.3397

TABLE 3a

Comparison of the breadths of the grains of the three varieties

GRAIN NO.	VARIETY		
	Inangel	(Inangel x Fortuna) F_1	Fortuna
	mm.	*mm.*	*mm.*
1	4.5	4.5	3.0
2	4.5	4.0	3.0
3	4.5	4.0	3.0
4	4.0	4.5	3.0
5	4.5	4.0	3.5
6	4.5	4.0	3.5
7	4.0	4.0	3.0
8	4.0	4.0	3.0
9	4.0	3.0	3.0
10	4.0	4.0	3.5
11	4.5	4.0	3.0
12	4.0	4.0	3.0
13	4.0	4.5	3.0
14	4.0	4.0	3.0
15	4.0	4.0	3.0
16	4.0	4.0	3.5
17	4.0	4.0	3.0
18	4.5	4.0	3.5
19	4.5	4.5	3.0
20	4.0	4.0	3.0
21	4.5	4.0	3.0
22	4.0	3.5	3.5
23	4.5	4.0	3.0
24	4.5	4.0	3.0
25	4.0	4.0	3.0
Total.....	105.5	101.5	78.0
Mean.....	4.22	4.06	3.12

TABLE 3b

Analysis of variance of the breadths of the grains of the three varieties

SOURCES OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F VALUE	
					.05	.01
Varieties.....	2	17.66	8.83	147.16	3.19	5.08
Individuals.....	24	1.17	0.05			
Error.....	48	2.67	0.06			
Total.....	74	21.50				

L.S.M.D. — 0.1391

EFFECTS OF VARYING LENGTH OF ILLUMINATION ON THE RATE OF GROWTH AND MORTALITY OF CHICKS[1]

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Of the Department of Agricultural Engineering

WITH ONE TEXT FIGURE

The use of electric light has produced profitable results in the increased egg production of layers during the winter months and in the stimulation of the growth of pullets. The advantages derived from the use of artificial lighting, however, have been limited to laying hens and to growing pullets. This study was undertaken to determine whether or not any advantage may be derived by artificially lighting growing chicks. The experiment was conducted in the Departments of Agricultural Engineering and Animal Husbandry from July, 1948, to March, 1949.

REVIEW OF LITERATURE

In separate experiments made on Barred Plymouth Rock chicks Lamoreux[2] in 1943, reported that in 1940 Carrick, Roberts, and Hienton and in 1941 Carrick, Hienton, and Roberts found that females exposed to normal daylight plus all-night illumination made slightly greater gains in weight than those exposed to normal daylight only. Lamoreux stated, however, that these authors reported the gains to be insignificant, similar to those that he observed in 1943 in a study on White Leghorn chicks. He further stated that "those (birds) less than nine weeks of age did not differ significantly in weight after exposure to fourteen hours or less than four hours of light daily."

In the Philippines Zaratan[3] in 1929, employed forced feeding on Cantonese chicks for fifteen minutes at night and observed that the beneficial influence of artificial lighting was manifested in the rapid growth of the chicks. Jongo[4] in 1948 reported that extra night feeding was not profitable in the production of green ducks.

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[1]Experiment Station Contribution No. 1532. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, April, 1949. Prepared in the Departments of Agricultural Engineering and Animal Husbandry under the direction of Assistant Professor A. P. Aglibut and Professor F. M. Fronda.

[2]LAMOREAUX, W. F. 1943. Influence of light on body weight of fowl. The U. S. Egg and Poultry Magazine **49** (**4**): 172–175.

[3]ZARATAN, ANANIAS. 1929. Studies on the effects on the growth of chicks of night feeding with the aid of artificial illumination. Philippine Agriculturist **18**: 387–396.

[4]JONGO, E. A. Effects of extra night feeding on the rate of growth of male ducklings. (Thesis presented for graduation with the Degree of Bachelor of Science from the College of Agriculture. 1948. Unpublished.)

MATERIALS AND METHODS

In this study, a total of 381 New Hampshire chicks were used: 105 for the first set, 132 for the second, and 144 for the third. Each set was randomly divided into three equal lots. Each lot was housed in a fireless brooder compartment which opened directly into the pen proper where the feed and water troughs were located. Rice hulls served as floor litter.

The three lots were equally exposed to daylight. Two of the three rearing lots were equipped with electric lighting systems, while the third, the check lot, received natural conditions of daylight. A 100-watt Mazda bulb provided with shade was suspended 1.22 m (four feet) directly above the center of the floor and the feed and water troughs. The galvanized iron walls of the different lots excluded the light from the adjacent pens. Electric switches were conveniently located outside the pens to control lighting in the lots. The lights of the experimental lots were put on daily at sunset, artificially lighting lot II for two hours and lot III for four hours. Lot I received normal daylight only.

Identical rations were given to all the lots, the ration consisting of the following ingredients, all parts by weight:

Rice bran	40 parts
Ground corn	35 "
Fish meal	20 "
Copra meal	5 "

Feed and water were made available to the birds at all times. Open-type feeding troughs were used to facilitate night feeding. Chopped green feed was given in adequate amounts three times a week from the time the chicks were two weeks old. From the seventh week the birds were provided with ground shells.

The initial weights of the chicks were taken when they were from twenty-four to forty-eight hours old. Subsequent biweekly weighings were made up to the termination of the experiment on the twelfth week. Records of the amount of feed consumed in the different lots, the mortality of the birds, and the occurrence of diseases were made.

RESULTS ANG DISCUSSION

Rate of growth. The normally lighted lot had the heaviest birds after twelve weeks (table 1 and fig. 1). The average final weights of the lots were 743.02 grams in lot I, 724.65 grams in lot II, and 640.26 grams in lot III. Subjected to the simple T-test, the difference in weights between lots I and II was insignificant under the 5-per cent level, while the difference between lot III and either lot I or II was significant under the 1-per cent level. With the heaviest lot as basis, the table shows that lot I was only 2.5 per cent more efficient than lot II but 13.8 per cent more efficient than lot III.

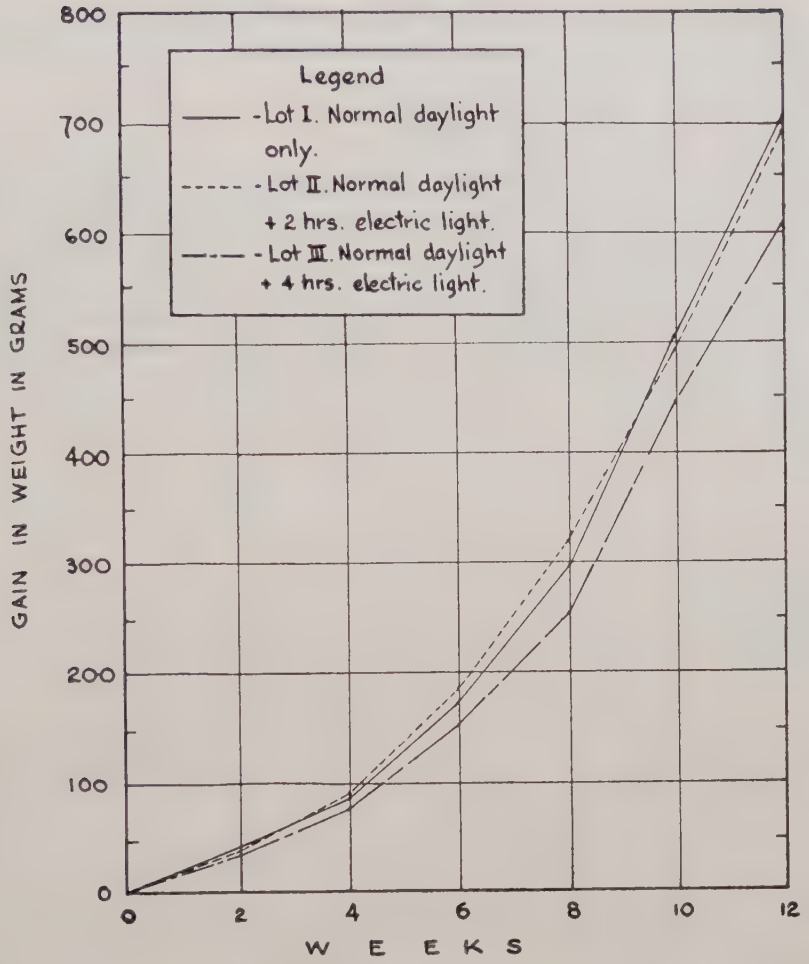

Fig. 1—Gains in weight in the different lots

Figure 1 indicates that the chicks which were given two hours of additional feeding after sunset, lot II, made slightly greater gains in body weight than either the control or the experimental lot III, which was given four hours of additional artificial light up to the eighth week. The maximum difference, which was 26.63 grams at the eighth week, was statistically insignificant as shown by the T-test under the 5-per cent level. Lot III fared poorly during the whole period of twelve weeks of study.

The following formula of Asmundson and Lerner[5] in 1942 for computing the average growth rate was employed:

$$R = \frac{W_2 - W_1}{\frac{1}{2}(W_2 + W_1)}$$

where W_2 and W_1 are the final and initial weights, respectively, for the period considered. The average total rates of growth were 181.34 per cent for lot I, 180.86 per cent for lot II, and 178.47 per cent for lot III. These figures show that the normally lighted birds grew faster by 0.48 per cent than the birds artificially lighted for two hours daily, and 2.87 per cent than those of lot III. The general tendency of the percentage rate of growth was to decrease as the birds grew older. Nevertheless, there appeared inconsistencies which may be explained by the incidence of diseases in the flock.

Mortality. More birds in lot II reached the age of twelve weeks than those in either lots I or III (table 2). The percentages of mortality were 46.72 in lot I, 38.69 in lot II, and 54.74 in lot III. Heavy mortality occurred from the fourth to the seventh week in all the lots. The main causes of deaths in the flock were the three major diseases usually suffered by growing chicks: chicken pox, roup, and coccidiosis. If the lot with the least mortality would be considered 100 per cent efficient, the relative efficiencies were 82.8 for lot 1, 100 for lot II, and 70.7 for lot III.

The birds in lot III were poor in vitality, thus making them the most susceptible to diseases. This condition of the chicks was apparently the result of excessive physical activity and shortened period of rest brought about by the artificially increased period of illumination. The additional two-hour feeding time appeared to have made the birds healthy; although some of the chicks suffered diseases, they were able to recover.

Feed consumption. As expected, the amount of feed consumed by the birds in the lots artificially lighted at night was more than that consumed by the birds in the normally lighted lot (table 3). The difference, however, between the amount of feed consumed in lot II and that in lot III was not so much as the difference between lots I and II, although in both cases there was a two-hour feeding time between the lots. The birds receiving 16 hours of light partook daily of the feed sparingly during the latter part of their feeding time.

The lighted lots required a greater amount of feed to produce a kilogram of gain in weight (table 3). Lot I required only 5.52 kilograms, while lot II required 6.29 kilograms and lot III, 7.32 kilograms. As the birds in lot III required the greatest amount of feed to produce a kilogram of gain

[5]Asmundson, V. S. and I. M. Lerner. 1942. Breeding chickens for meat production. California Agric. Exper. Sta. Bull. 675: 1–45.

in weight, more of the feed consumed was apparently used to maintain rather than increase the body weight. Lot I seemed to have transformed more feed into body weight, as it was 12.2 per cent more efficient than lot II and 38.3 percent more efficient than lot III, basing on the lot which required the least amount of feed to produce a kilogram gain. Lamoreux[5] cites Dakan's statement in 1934 that "additional feeding time (for hens) is not important" seems also applicable to chicks.

Returns above feed and lighting costs. Table 4 gives the returns above the feed and lighting costs based on 100 birds weaned. This table shows that the returns in lot I was higher than that in lot II by ₱23.68. Lot III incurred a loss of ₱20.75 because the sale of much lighter birds failed to offset the cost of more feed and more electric current consumed. As this study was treated experimentally, no expenses for labor were included. The returns above the cost of feed and electrical energy consumed will just indicate the relative effects of artificial illumination on the economics side of this study.

SUMMARY

1. At the weaning age of twelve weeks, there was no significant difference between the weight of the chicks given normal daylight only and those given an additional two hours of artificial illumination. The chicks given normal daylight were, however, significantly heavier than those which received normal daylight plus four additional hours of electric light.

2. The average growth rate of the birds which received normal daylight was 181.34 per cent; that which received normal daylight plus two hours artificial light was 180.88 per cent; and that of the birds which received natural daylight plus four hours artificial light was 178.47 per cent.

3. The percentages of mortality in the different lots were as follows: 46.72 in the lot given normal daylight, 38.69 in the lot given normal daylight and two hours artificial light, and 54.74 in the lot given normal daylight and four hours of artificial light.

4. The lots given artificial light in addition to the normal daylight consumed more feed than the lot that received normal daylight only.

5. The returns above the cost of feed and lighting were much higher in the normally lighted lot than in the lot which received normal daylight plus two hours of artificial light. The birds given an additional four hours of artificial illumination after sunset gave returns much less than the cost of feed and electric current consumed.

6. It is apparent that lengthening the day or the period of illumination by the use of electric light does not have any beneficial influence on the growth of chicks.

[5]Lamoreux, op. cit.

TABLE 1

Average biweekly weights of the different lots

AGE	LOT I	LOT II	LOT III
	grams	*grams*	*grams*
1 day	36.31∓ 0.31	35.95∓ 0.30	36.42∓ 0.33
2 weeks	75.59∓ 1.00	74.94∓ 1.00	73.44∓ 0.99
4 weeks	120.08∓ 2.35	125.07∓ 2.37	111.07∓ 1.94
6 weeks	210.60∓ 4.84	224.00∓ 5.23	188.86∓ 5.51
8 weeks	329.92∓11.87	356.55∓ 9.40	292.70∓13.33
10 weeks	538.98∓18.61	526.62∓17.79	484.02∓19.30
12 weeks	743.02∓25.18	724.65∓22.67	640.26∓24.61
Relative efficiency, per cent[a]	100	97.5	86.2

[a]Considering the lot with the heaviest weanlings as 100 per cent efficient.

TABLE 2

Percentage of mortality in the different lots

ITEMS	LOT I	LOT II	LOT III
Number of chicks at start	137	137	137
Number of weanlings at twelve weeks	73	84	62
Number of chicks that died	64	53	75
Percentage of mortality	46.72	38.69	54.74
Relative efficiency, per cent[a]	82.80	100	70.70

[a]Considering the lot with the least mortality as 100 per cent efficient.

TABLE 3

Amount of food required to produce a kilogram gain

ITEMS	LOT I	LOT II	LOT III
Average weight of 100-day-old chicks, kilograms	3.63	3.60	3.64
Average weight of 100 weanlings at twelve weeks, kilograms	74.30	72.47	64.02
Average gain in weight, kilograms	70.67	68.87	60.38
Total feed consumed by 100 chicks in twelve weeks, kilograms	390.39	433.36	441.76
Feed required to produce a kilogram gain, kilograms	5.52	6.29	7.32
Relative efficiency, per cent[a]	100	87.8	61.7

[a]Considering the lot that required the least amount of feed to produce a kilogram gain as 100 per cent efficient.

TABLE 4

Returns above feed and lighting costs based on 100 birds

ITEMS	LOT I	LOT II	LOT III
Total amount of feed consumed, kilograms	390.39	433.36	441.76
Total cost of the feed, pesos	119.85	133.04	135.62
Total amount of electric current consumed, kilowatt-hours	—	45.6	101.3
Total cost of electric current consumed, pesos	—	5.93	13.17
Total cost of feed and electrical current consumed, pesos	119.85	138.97	148.79
Weanlings produced, kilograms	74.30	72.47	64.02
Returns from the sale of weanlings, pesos	148.60	144.94	128.04
Returns above feed and lighting costs, pesos	28.75	5.07	–20.75

COLLEGE AND ALUMNI NOTES

Dean L. B. Uichanco was one of the speakers at the forum on higher education on February 12, 1949, which was held in the new U. P. site, Diliman, Quezon City, in connection with the fortieth anniversary of the founding of the University of the Philippines.

A big delegation from the College attended the forum and the U. P. special commencement exercises held on the same day.

Dr. Valente Villegas, head of the Department of Animal Husbandry, was recently elected Socio corrispondente, Societa Italiana per il Progresso della zootecnia Milano, Italy, and Socio correspondiente, Sociedad veterinaria de zootecnia, Madrid, Spain.

Prof. Leland H. Taylor, of the Department of Biology, West Virginia University, sent three boxes of books to the Philippine Embassy in Washington, for transmission to the College. Professor Taylor is a friend and a former fellow student of Dean Uichanco at Harvard.

Dr. Stanley W. Warren of the Department of Agricultural Economics at Cornell University donated another set of books. These were sent to the Philippine Embassy in Washington, according to a letter received by Dr. F. M. Sacay, a close friend of Dr. S. W. Warren.

The 182nd regular scientific meeting of the Los Baños Biological Club was held on January 28, 1949, at the Agricultural Engineering Lecture Hall. The following paper was read and discussed in the meeting: "An Economic and Social Study of Tobacco Farmers in Isabela" by Dr. F. M. Sacay and Messrs. Q. T. Tagorda and G. Fernandez, of the Department of Agricultural Education.

At the 183rd regular scientific meeting held on February 25, 1949, at the Entomology Lecture Hall, Dr. Julian Banzon of the Department of Agricultural Chemistry read "Reversal Processing of Cinematographic Film under Tropical Conditions".

At the 184th regular scientific meeting held on March 25, 1949, at the Engineering Lecture Hall, "The Behavior of a Promising Imported Variety of Poinsettia under Los Baños Conditions" was read by Dr. Leon G. Gonzalez of the Department of Agronomy.

Professor Calixto Mabesa of the School of Forestry and Dr. Mariano Mondoñedo of the Department of Animal Husbandry were unanimously elected new president and secretary, respectively, of the club. Dr. Nicolas L. Galvez of the Department of Soils is the outgoing president, and Professor Mabesa, the former secretary.

Mr. Burton T. Oñate, '47, of the Department of Agricultural Engineering, left for the United States on February 21, 1949, as U. P. fellow to take advanced courses in physics and mathematics at the University of Chicago.

Mr. Ramon Samaniego, '40, topped the provincial agricultural supervisor's examination, according to the list recently released by the Bureau of Civil Service.

All the instructors in the Department of Agricultural Education of the College who took the same test were among the 234 successful examinees. They are Messrs. Pelagio S. Fajardo, '44, Martin V. Jarmin, '40, Gil F. Saguiguit, '47, and Quirino T. Tagorda, '48.

Mr. Celestino P. Habito, '44, resigned as assistant instructor in the Department of Animal Husbandry on March 1, 1949, to accept the job as manager of the Marival Poultry Farm in Mariquina, Rizal.

Mr. Amado C. Campos, '49, succeeded Mr. Habito in the Department of Animal Husbandry on December 6, 1948.

Mr. Lim Cheng Chong, member of the Legislative Yuan of China, was a recent campus visitor. He was accompanied by Mr. Lim Tek-goan of San Pablo City.

The annual botanical trip to the summit of Mt. Maquiling for students taking plant physiology, was made on March 12–13, 1949, under the guidance of Dr. Rafael B. Espino and Mr. Iluminado Valencia of the Department of Agricultural Botany.

The Shell Company, which deals in chemicals and insecticides, needs the services of a graduate who has a good working knowledge of entomology and plant pathology, according to a letter received by Dean Uichanco. Interested parties may communicate with the company, P. O. Box 441, Manila.

Undersecretary of Agriculture José S. Camus, '14, was the chairman of the Philippine delegation to the International Rice Commission conference which began on March 7, 1949, in Bangkok, Siam. The technical advisers were Dr. Francisco O. Santos, '19, Mr. Victorino Borja, '34, and Mr. Trinidad Alconcel, '38. The delegation returned by plane on March 24, 1949.

Professor Marcelo V. Arnaldo, '27, is on the faculty of the College of Business Administration, Silliman University, Dumaguete, Negros Oriental.

Major Conrado B. Uichanco, '33, of the Armed Forces of the Philippines, was a campus visitor on March 25, 1949.

Educational trips were made by four different classes to various places on February 5, 1949. Headed by Dr. V. Villegas, Dr. F. S. Mensalvas, and Mr. C. P. Habito, the students of Animal Husbandry 4 and Animal Husbandry 105 visited the studs of Mr. Santos Sarmiento and the Delros stud

at Lipa City, and the Batangas Breeding Station. Race horses in two barrios of Lipa City were also studied. The class in Agronomy 21, under Mr. V. M. Dawis, visited the commercial flower shops and nurseries in Manila, the Malacañan Park, and the new U. P. site in Diliman, Quezon City. The freshmen class, headed by Dr. S. M. Cendaña, the adviser, and Amado Arevalo, the class president, made an educational trip to Manila and Diliman. The Rural High School economics class under Mr. N. B. Tablante visited the Franklin Baker Company, the San Pablo Oil Factory, and the Coconut Experiment Station in San Pablo City. Miss Nelly Dunglao joined the trip as chaperon.

The annual report of Dean Uichanco for the year ending June 4, 1946, was published as a leading article in the Winter, 1949, number of *The Pacific Spectator*. Dean Copeland happened to get a copy of the annual report, and, considering it as "a remarkable historical document" (of the College in World War II), submitted it to the editor, who readily saw its worth for publication.

Dr. Floyd W. Reeves, head of the UNESCO consultative educational mission to the Philippines, and Professors Paul R. Hanna and A. C. Lewis, members, were campus visitors on March 5, 1949. They were accompanied by Mrs. Hanna. The heads of the technical departments of the College held a luncheon-conference with the guests at the AWS Clubhouse.

Dr. F. M. Fronda, of the Department of Animal Husbandry, has accepted the invitation of the World's Poultry Science Association to serve as member of the publication committee of the *World's Poultry Science Journal*. Doctor Fronda will be in charge of the area covering the Philippines, Japan, and China.

A summer institute for teachers of agriculture was held on the campus last summer 1949. The primary purpose of the institute was to raise the technical and professional qualifications of agricultural teachers. Courses for both college graduates and undergraduates were offered.

Mr. Charat Suntarasing, (Charas Sundarasinha, '28), Vice-Dean of the College of Agriculture of Siam, sent to the Copeland Travel Fund Committee through Dr. V. Villegas, contributions collected from 19 graduates and former students of the College at the instance of President Luan Suwan (Thongdee Resanonda, '24).

Mr. Jesús P. Mamisao, '30, soil scientist of the Division of Soil Survey and Conservation and member of the National Policy Association, read a paper on soil conservation problems before the association recently, and later, before the Philippine Cultural Society.

Mr. Jorge Mendoza, '25, is in charge of the Batangas Horse Breeding Station. An authority on horses, he has been engaged in horse breeding

for about seventeen years. Among the animals in his charge are four Australian Thoroughbred stallions which rank among the best in the Islands.

Mr. Pedro S. Paje, '27, superintendent of the Iwahig Penal Colony, visited the College on March 7, 1949.

Dr. Edwin Bingham Copeland, founder and first dean of the College of Agriculture, was a special guest at the eighteenth commencement exercises of the Rural High School held on April 20, 1949, at the Rural High School Auditorium. Introduced by President B. M. Gonzalez, Dean Copeland spoke touchingly of reminiscences of his early days at the College.

Congressman Juan de G. Rodriguez of Pangasinan, a former student of the College, delivered the commencement address. He was introduced by Dean L. B. Uichanco. President Gonzalez awarded the diplomas to 23 boys and 18 girls. Martin E. Raymundo and Zenaida V. Alcala were the valedictorians in the boys' and girls' curriculum, respectively.

The Rural High School student body honored the new graduates with a ball at the Seniors' Social Garden on the evening of April 20, 1949.

The Maquiling School celebrated its silver anniversary with a four-day program of various activities as follows: academic contest on April 18; folk dances and amateur hour on April 19; calisthenics, drill, and group games on April 20; open house, closing exercises, and patrons-alumni homecoming luncheon on April 23, 1949. Dean Uichanco, President of the Board of Trustees, awarded certificates to 22 new graduates during the closing exercises. Among those present in the luncheon were Dr. Edwin Bingham Copeland and five former teachers of the Maquiling School, namely; Mrs. Concepcion R. Gonzalez, Mrs. Maria Mondoñedo, Miss Lina E. Velmonte, Miss Manuela T. Amparo, and Miss Zoila Reyes.

With Dean L. B. Uichanco as guest of honor, a physical education-letter men day was held last March 29 at the College athletic field. Dr. R. B. Espino, president of the Sub-Board of Athletic Management, awarded prizes to individual, group or class winners in various athletic competitions. The prizes consisted of pennants, the Chipeco Cup, medals, and College letters.

Mr. J. K. Waller, Australian consul-general to the Philippines, was a campus visitor on April 1, 1949. He was accompanied by Mr. Severino Hermosura, '39, of the College of Veterinary Science, U.P. The visitors had lunch with Dean and Mrs. Uichanco.

Director-General Norris E. Dodd of the FAO was a recent campus visitor. In a letter of appreciation forwarded to Dean Uichanco, Mr. Dodd mentioned the College, "where the scenery is among the best in the world," as one of the places he would enjoy seeing again.

Mr. T. C. Morehouse, vice-president of the MacMillan Company, visited the College on April 6, 1949.

Dr. Bienvenido M. Gonzalez, '13, founder and first president of the Maquiling School, was presented a commemorative plaque by Dean Uichanco, in behalf of a grateful community, on the occasion of the silver anniversary and closing exercises of the school on April 23, 1949, at the Rural High School Auditorium. The presentation was made in recognition of President B. M. Gonzalez' foresight, educational leadership, and inspiring guidance.

Dr. Leopoldo B. Uichanco, '15, was the guest of honor at a birthday party given him by the College faculty and employees on the evening of April 23, 1949, at the Rural High School Auditorium.

The College faculty recommended the graduation of 22 students for the degree of Bachelor of Science in Agriculture in a meeting held on April 12, 1949. The new graduates are as follows: Pablo J. Alfonso, Jr., Avelino E. Bigornia, Laureano O. Bondoc, Carlos R. Casal, Celso T. Catambay, Paulino F. Cayco, Crescenciano F. de la Cruz, Ildefonso M. Cruz, Marcos A. de la Cruz, Felipe C. Galeon, Gabriel A. Garcia, Pedro R. Garcia, Emiliano P. Gianzon, Esdras G. Gines, Teodoro A. Irabagon, Silvestre V. Javier, Jr., Irineo B. Mendoza, Felix C. Palis, Leonardo A. Paulino, Francisco T. Ramos, Mariano A. Sandoval, and Almario C. de los Santos.

The recommendation for graduation of the following students for the title of Associate in Agriculture was also approved: Marciano A. Aquino, Godofredo B. Ramos, Jaime A. Sandique, and Antonio M. Zosa.

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